SCHEME : K

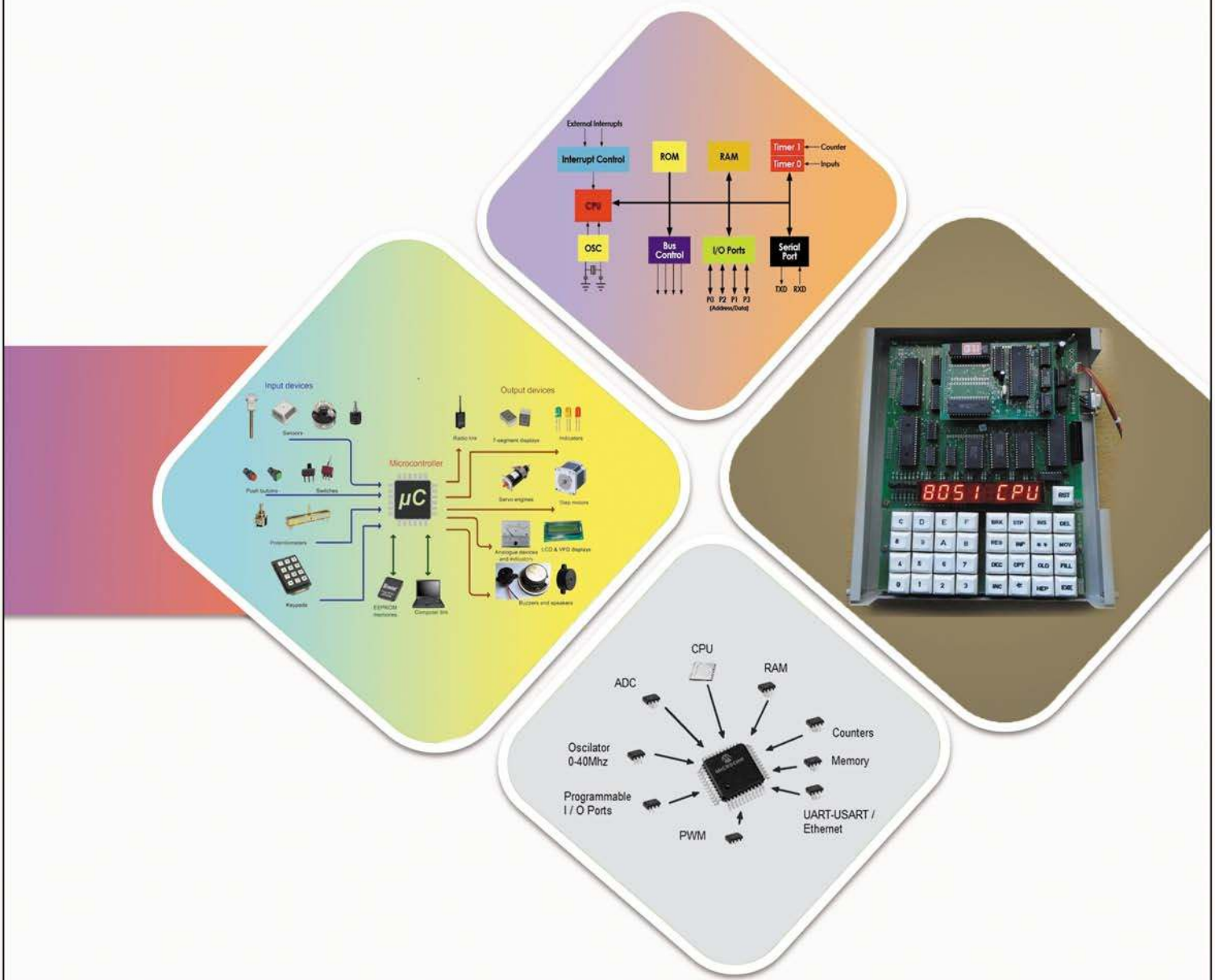
Name : _____

Roll No. : _____ Year : 20___ 20___

Exam Seat No. : _____

# LABORATORY MANUAL FOR

# MICROCONTROLLER & APPLICATIONS (314328)




## ELECTRONICS ENGINEERING GROUP


MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION, MUMBAI

(Autonomous) (ISO 9001: 2015) (ISO/IEC 27001:2013)

## VISION

To ensure that the Diploma Level Technical Education constantly matches the latest requirements of technology and industry and includes the all-round personal development of students including social concerns and to become globally competitive, technology led organization.

## MISSION

To provide high quality technical and managerial manpower, information and consultancy services to the industry and community to enable the industry and community to face the changing technological and environmental challenges.

## QUALITY POLICY

We, at MSBTE, are committed to offer the best in class academic services to the students and institutes to enhance the delight of industry and society. This will be achieved through continual improvement in management practices adopted in the process of curriculum design, development, implementation evaluation and monitoring system along with adequate faculty development Programs.

## CORE VALUES

MSBTE believes in the followings:

- Education industry produces live products.
- Market requirements do not wait for curriculum changes.
- Question paper is the reflector of academic standards of educational organization
- Well-designed curriculum needs effective implementation too.
- Competency based curriculum is the backbone of need based programs.
- Technical skills do need support for life skills.
- Best teachers are the national assets.
- Effective teaching learning process is impossible without learning resources.

A Laboratory Manual for

**Electronics Engineering group**

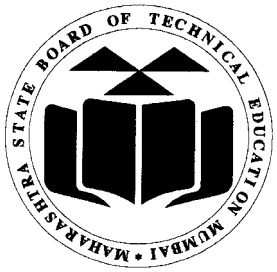
# Microcontroller and Applications

# (314328)

# Semester-IV

**(AO,DE,EJ,EK,ET,EX,IC,IE,IS,TE)**

**Maharashtra State**
**Board of Technical Education, Mumbai**
**(Autonomous) (ISO-9001-2008) (ISO/IEC 27001:2013)**




# Maharashtra State
# Board of Technical Education, Mumbai

**(Autonomous) (ISO-9001-2008) (ISO/IEC 27001:2013)**

**4th Floor, Government Polytechnic Building, 49, Kherwadi,**
**Bandra (East), Mumbai – 400051.**

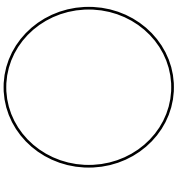
# Maharashtra State
# Board of Technical Education

## Certificate

This is to certify that Mr. / Ms …….
Roll No…….of …… Semester of Diploma in ……of Institute…….
(Code…….) has attained pre-defined practical outcomes (PROs) satisfactorily in course **Microcontroller and Applications (314328)** for the academic year 20…….to 20…..... as prescribed in the curriculum.

Place ……. Enrollment No……
Date: ..... Exam Seat No. ……..

**Course Teacher** **Head of the Department** **Principal**



# Preface

The primary focus of any engineering laboratory/ field work in the technical education system is to develop the much needed industry relevant competencies and skills. With this in view, MSBTE embarked on this innovative 'K' Scheme curricula for engineering diploma programmes with outcome-based education as the focus and accumulator ordinally, relatively large amount of time is allotted for the practical work. This displays the great importance of laboratory work making each teacher; instructor and student to realize that every minute of the laboratory time need to be effectively utilized to develop these outcomes, rather than doing other mundane activities. Therefore, for the successful implementation of this outcome-based curriculum, every practical has been designed to serve as a ***'vehicle'*** to develop this industry identified competency in every student. The practical skills are difficult to develop through 'chalk and duster' activity in the classroom situation. Accumulator ordinally, the 'K' scheme laboratory manual development team designed the practical's to ***focus*** on the ***outcomes***, rather than the traditional age old practice of conducting practical's to 'verify the theory' (which may become a by-product along the way).

This laboratory manual is designed to help all stakeholders, especially the students, teachers and instructors to develop in the student the pre-determined outcomes. It is expected from each student that at least a day in advance, they have to thoroughly read through the concerned practical procedure that they will do the next day and understand the minimum theoretical background associated with the practical. Every practical in this manual begins by identifying the competency, industry relevant skills, course outcomes and practical outcomes which serve as a key focal point for doing the practical. The students will then become aware about the skills they will achieve through procedure shown there and necessary precautions to be taken, which will help them to apply in solving real-world problems in their professional life.

This manual also provides guidelines to teachers and instructors to effectively facilitate student-centered lab activities through each practical exercise by arranging and managing necessary resources in order that the students follow the procedures and precautions systematically ensuring the achievement of outcomes in the students.

Microcontroller is used in almost all the domestic, industrial, consumer goods and other high end products. Automation is used in every field of engineering and microcontroller is inbuilt element of these systems and devices. Diploma engineers have to deal with various microcontroller based systems and maintain them. This course is intended to develop the skills to maintain and solve the application problems related to microcontrollers.

The lab manual development team wishes to thank MSBTE who took initiative in the development of curriculum re-design project and implementation and also acknowledge the contribution of individual course experts who have been involved in laboratory manual as well as curriculum development (I scheme) directly or indirectly. The National Institute of Technical Teachers' Training and Research, Bhopal deserves our sincere appreciation for the guidance provided.

Although all care has been taken to check for mistakes in this laboratory manual, yet it is impossible to claim perfection especially as this is the first edition. Any such errors and suggestions for improvement can be brought to our notice and are highly welcome.

## Programme Outcomes (POs) to be achieved through Practical of this Course

Following programme outcomes are expected to be achieved through the practical of the course

**PO 1. Basic and Discipline specific knowledge**: Apply knowledge of basic mathematics, sciences and engineering fundamentals and engineering specialization to solve the engineering problems.

**PO 2. Problem analysis:** Identify and analyze well-defined engineering problems using codified standard methods.

**PO 3. Design/Development of solutions:** Design solutions for well-defined technical problems and assist with the design of system components or processes to meet specified needs.

**PO 4. Engineering tools, Experimentation and Testing:** Apply modern engineering tools and appropriate technique to conduct standard tests and measurements.

**PO 5. Engineering practices for society, sustainability and environment:** Apply appropriate technology in context of society, sustainability, environment and ethical practices.

**PO 6. Project Management**: Use engineering management principles individually, as a team member or a leader to manage projects and effectively communicate about well-defined engineering activities.

**PO 7. Life-long learning:** Ability to analyze individual needs and engage in updating in the context of technological challenge.

# List of Industry Relevant Skills

The following industry relevant skills of the competency '**Maintain microcontroller-based systems**' are expected to be developed in students by undertaking the practical's of this laboratory manual.

1. Identify the relevant microcontroller.
2. Interface various I/O devices with microcontroller.
3. Interpret the program.
4. Maintain microcontroller-based systems.
5. Use features available with given microcontroller.
6. Test the circuit for the given application.
7. Find faults and trouble shoot the given system.

## Practical- Course Outcome matrix

**Course Outcomes (COs)**

**a.** Interpret architecture of 8-bit microcontrollers.
**b.** Develop program in 8051in assembly language for the given operations.
**c.** Develop program using timers and interrupt.
**d.** Interface the memory and I/O peripherals to 8051 microcontrollers.
**e.** Maintain microcontroller-based application

| Sr No. | Laboratory Experiment / Practical Titles / Tutorial Titles | CO a. | CO b. | CO c. | CO d. | CO e. |
|---|---|---|---|---|---|---|
| **1.** | *Identification of various blocks of 8051 microcontroller development board. | √ | - | - | - | - |
| **2.** | Assembly language program using various addressing modes. | - | √ | - | - | - |
| **3.** | *ALP to perform arithmetic operations on 8-bit data. | - | √ | - | - | - |
| **4.** | *ALP to perform arithmetic operations on 16-bit data. | - | √ | - | - | - |
| **5.** | *ALP to perform addition of BCD Data. | - | √ | - | - | - |
| **6.** | *ALP for series addition. | - | √ | - | - | - |
| **7.** | *Array data transfer from source locations to destination locations. | - | √ | - | - | - |
| **8.** | *Block exchange of data from source locations to destination locations. | - | √ | - | - | - |
| **9.** | *Finding the smallest number from the given data bytes. | - | √ | - | - | - |
| **10.** | Finding the largest number from the given data bytes. | - | √ | - | - | - |
| **11.** | *Arranging the number in ascending order. | - | √ | - | - | - |
| **12.** | Arranging the number in descending order | - | √ | - | - | - |
| **13.** | *Generate delay using Timer register. | | | √ | | |
| **14.** | *Serial 8-bit data transfer on serial port. | | | √ | | |
| **15.** | LED interfacing to 8051 | | | | √ | |

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| Sr No. | Laboratory Experiment / Practical Titles / Tutorial Titles | CO a. | CO b. | CO c. | CO d. | CO e. |
|---|---|---|---|---|---|---|
| **16.** | Generating pulse and square wave using Timer delay. | - | - | - | √ | - |
| **17.** | LED matrix Interfacing to 8051. | - | - | - | √ | - |
| **18.** | *Seven-segment display interface for displaying the decimal numbers. | - | - | - | √ | - |
| **19.** | *Relay interfacing to Microcontroller. | - | - | - | √ | - |
| **20.** | *LCD interfacing to 8051 to display characters and decimal number. | - | - | - | √ | - |
| **21.** | Keyboard interfacing to 8051. | - | - | -- | √ | - |
| **22.** | * ADC interfacing to 8051. | - | - | - | √ | - |
| **23.** | *DAC Interfacing to generate the square waveform. | - | - | - | - | √ |
| **24.** | DAC Interfacing to generate the triangular waveform. | - | - | - | - | √ |
| **25.** | *Stepper Motor Interfacing to 8051. | - | - | - | - | √ |
| **26.** | Stepper Motor Interfacing to 8051 for rotating anti-clockwise | - | - | - | - | √ |
| **27.** | Water Level controller using 8051. | - | - | - | - | √ |
| **28.** | Temperature Sensor Interfacing to detect and measure temperature. | - | - | - | - | √ |

## Guidelines to Teachers

1. Teacher is expected to refer complete curriculum document and follow guidelines for implementation
2. Teacher should provide the guideline with demonstration of practical to the students with all features.
3. Teacher shall explain prior concepts to the students before starting of each practical
4. Involve students in performance of each practical.
5. Teacher should ensure that the respective skills and competencies are developed in the students after the completion of the practical exercise.
6. Teachers should give opportunity to students for hands on experience after the demonstration.
7. Teacher is expected to share the skills and competencies to be developed in the students.
8. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected the students by the industry.
9. Give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions.
10. Assess the skill achievement of the students and COs of each unit.
11. At the beginning Teacher should make the students acquainted with any of the simulation software environment as few experiments are based on simulation.
12. It is desirable to paste the photo of actual experimental setup or draw block diagram of experimental setup.
13. Practical No.1 should not be consider for Practical (ESE-End Semester Exam).
14. Conduct workshops teaching students how to safely and properly dispose of electronic waste, fostering a culture of sustainability within the lab environment.
15. Introduce zero-waste challenges where students are encouraged to create projects using only recycled or repurposed components from existing e-waste, promoting creativity and resourcefulness.

## Instructions for Students

1. Listen carefully the lecture given by teacher about course, curriculum, learning structure, skills to be developed.
2. Before performing the practical student shall read lab manual of related practical to be conducted.
3. For incidental writing on the day of each practical session every student should maintain a ***dated log book*** for the whole semester, apart from this laboratory manual which s/he has to ***submit for assessment to the teacher***.
4. Organize the work in the group and make record of all observations.
5. Students shall develop maintenance skill as expected by industries.
6. Student shall attempt to develop related hand-on skills and gain confidence.
7. Student shall develop the habits of evolving more ideas, innovations, skills etc. those included in scope of manual

8. Student shall refer technical magazines, IS codes and data books.
9. Student should develop habit to submit the practical on date and time.
10. Student should well prepare while submitting write-up of exercise.

# Content Page

List of Practical's and Progressive Assessment Sheet

| Sr No | Title of the practical | Page No. | Date of performance | Date of submission | Assessment marks (25) | Dated sign. of teacher | Remarks (if any) |
|---|---|---|---|---|---|---|---|
| 1 | *Identification of various blocks of 8051 microcontroller development board. | | | | | | |
| 2 | Assembly language program using various addressing modes. | | | | | | |
| 3 | *ALP to perform arithmetic operations on 8- bit data. | | | | | | |
| 4 | *ALP to perform arithmetic operations on 16-bit data. | | | | | | |
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| 7 | *Array data transfer from source locations to destination locations. | | | | | | |
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| 9 | *Finding the smallest number from the given data bytes. | | | | | | |
| 10 | Finding the largest number from the given data bytes. | | | | | | |
| 11 | *Arranging the numbers in ascending order. | | | | | | |
| 12 | Arranging the numbers in descending order | | | | | | |
| 13 | *Generate delay using Timer register. | | | | | | |
| 14 | *Serial 8-bit data transfer on serial port. | | | | | | |
| 15 | LED interfacing to 8051 | | | | | | |
| 16 | Generating pulse and square wave by using Timer delay. | | | | | | |
| 17 | LED matrix Interfacing to 8051. | | | | | | |
| 18 | *Seven-segment display to interface for displaying the decimal number. | | | | | | |
| 19 | *Relay interfacing to Microcontroller. | | | | | | |

| Sr No | Title of the practical | Page No. | Date of performance | Date of submission | Assessment marks (25) | Dated sign. of teacher | Remarks (if any) |
|---|---|---|---|---|---|---|---|
| 20 | *LCD interfacing of 8051 to display the characters and decimal numbers. | | | | | | |
| 21 | Keyboard interfacing to 8051. | | | | | | |
| 22 | * ADC interfacing to 8051. | | | | | | |
| 23 | *DAC Interfacing to generate the square waveform. | | | | | | |
| 24 | DAC Interfacing to generate the triangular waveform. | | | | | | |
| 25 | *Stepper Motor Interfacing to 8051. | | | | | | |
| 26 | Stepper Motor Interfacing to 8051 for rotating anti-clockwise | | | | | | |
| 27 | Water Level controller using 8051. | | | | | | |
| 28 | Temperature Sensor Interfacing to detect and measure temperature | | | | | | |
| **Total Marks** | | | | | . | | |

- *The practical marked as '*' are compulsory,*
- Column 6th marks to be transferred to Performa of CIAAN-2017.

# Practical No. 1: Identification of various blocks of 8051 microcontroller development board

## I. Practical Significance

Microcontroller has wide application in electronic system needing real time processing/control, starting from domestic application such as washing machine, TV and air conditioners. They are also used in automobiles, process control industries, cell phones, robotics and in space application.

## II. Industry/Employer Expected Outcome(s)

Maintain microcontroller-based systems.

## III. Course Level Learning Outcome(s)

Interpret architecture of 8-bit microcontrollers.

## IV. Laboratory Learning Outcome(s)

Identify the functions of various blocks of 8051microcontroller development board

## V. Relevant Affective Domain related outcome(s)

1. Demonstrate working as a leader/a team member.
2. Maintain tools and equipment.
3. Follow ethical practices.

## VI. Relevant Theoretical Background

Microcontroller is a single chip microcomputer made through VLSI fabrication. 8051 is the first microcontroller of the MCS-51 family introduced by Intel Corporation.

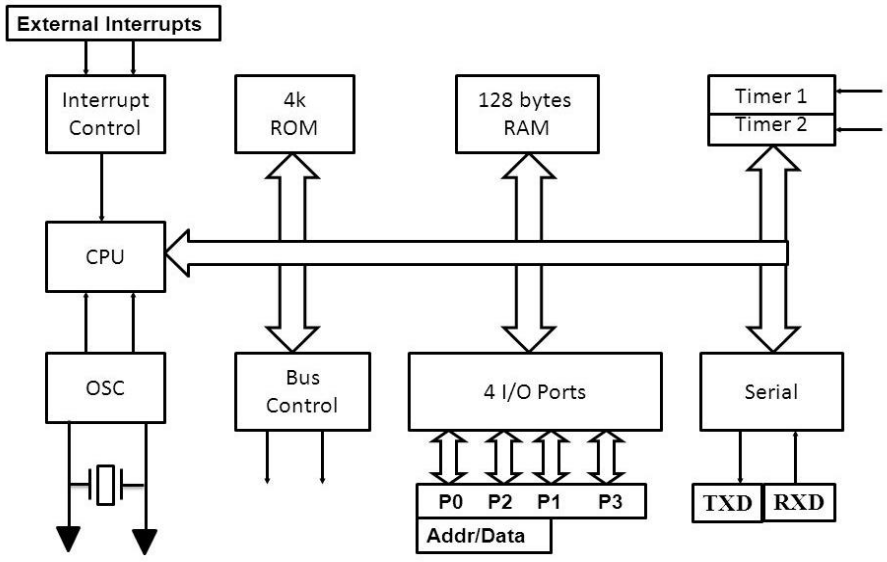



**Fig 1.1 Block diagram of 8051**

It has inbuilt components such as CPU, internal RAM and ROM, timers/counters, serial ports, interrupts and I/O ports. AT80C51 is compatible with MCS-51. The 8051 is an 8-bit processor. The CPU can work on only 8 bits of data at a time.

**Specification of microcontroller 8051**

1. It is an 8-bit microcontroller
2. It has 128 bytes of Internal RAM
3. It has 4 kilo bytes of Internal ROM
4. It has two 16-bit internal timers/counters
5. It has four 8-bit parallel ports
6. It has one full duplex serial port
7. It has three internal and two external interrupts.

**Pin diagram of 8051:** 8051 is a 40 pin IC and operates on +5 volts DC supply.

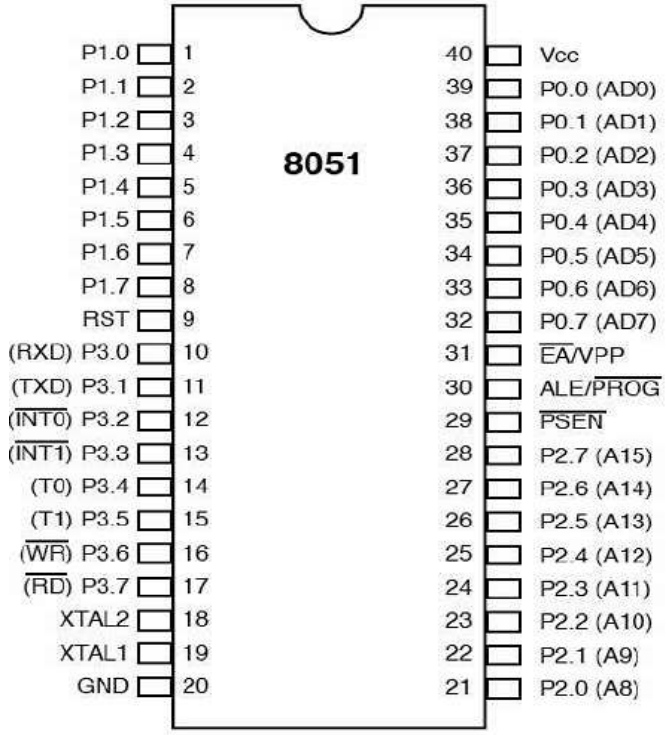



**Fig. 1.2 Pin diagram of 8051**

**Keil IDE**

Keil is 8051 development tool which includes a text Editor, Assembler Debugger, linker, Simulator, C-complier, hex converter, locator and some in-built features like logic analyzer to observe various waveforms. It also includes terminal emulator. Keil supports all 8051 derivatives and valuable tool for embedded software development.

## The Development board

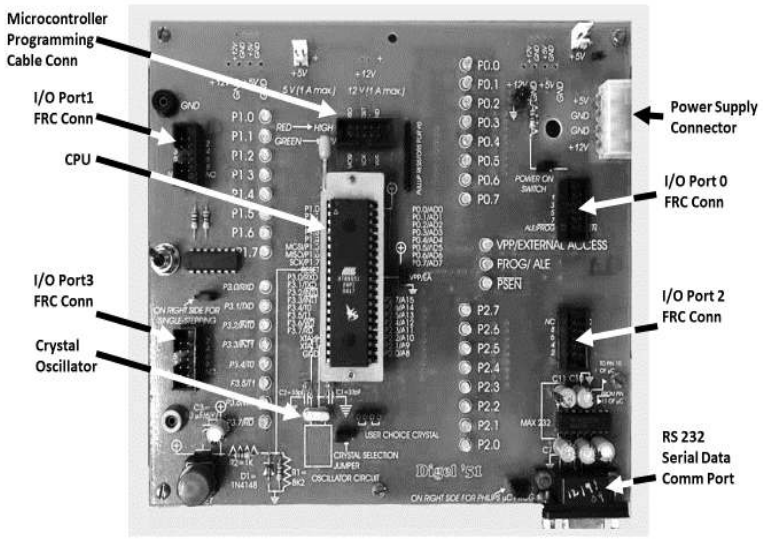



**Fig. 1.3 8051 Development Board**

The development board has 8051 microcontrollers along with some necessary component like MAX 232, resistor network etc. It is a devise used to develop and design a prototype embedded system. Port pins are taken out for interfacing various peripherals. It has a provision to download the hex file of user program which is generated by Keil or any other IDE. FLASH MAGIC software is used to download the hex file into the code memory of microcontroller.


**Fig. 1.4 8051 Programming through serial cable**

## VII. Resources required

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Microcontroller kit | Single board system with 8K RAM,ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler,RS-232,USB, interfacing facility with built in power supply. | 1 No. |
| 2. | Desktop PC | Loaded with open-source IDE, simulation and program downloading software. | 1 No. |

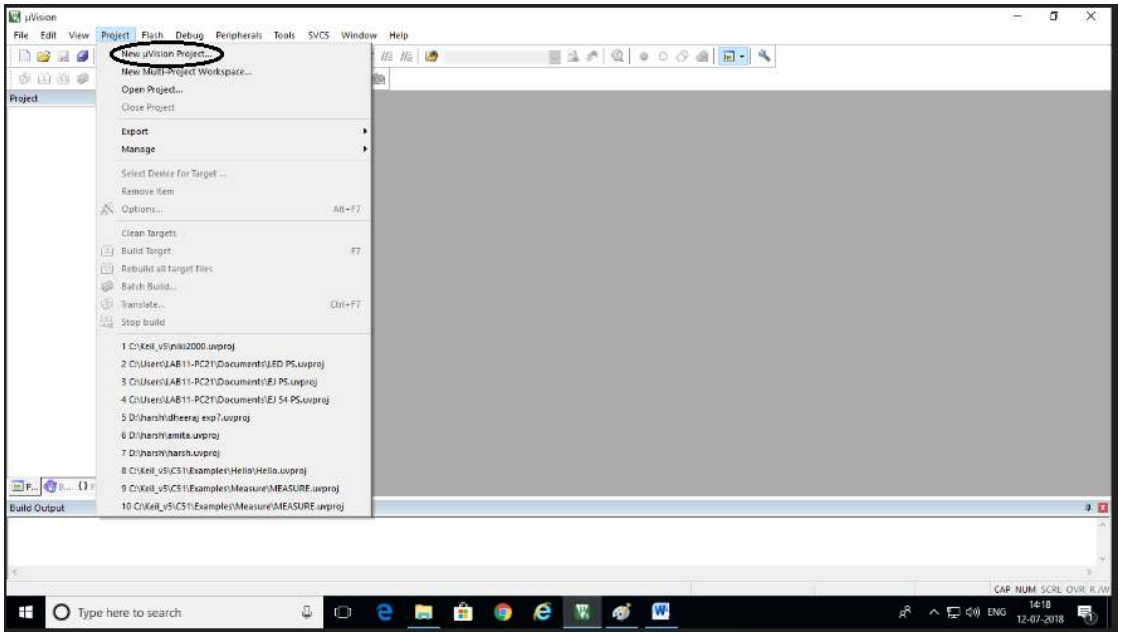
## VIII. Precautions to be Followed

Do not power up development board when identifying block.

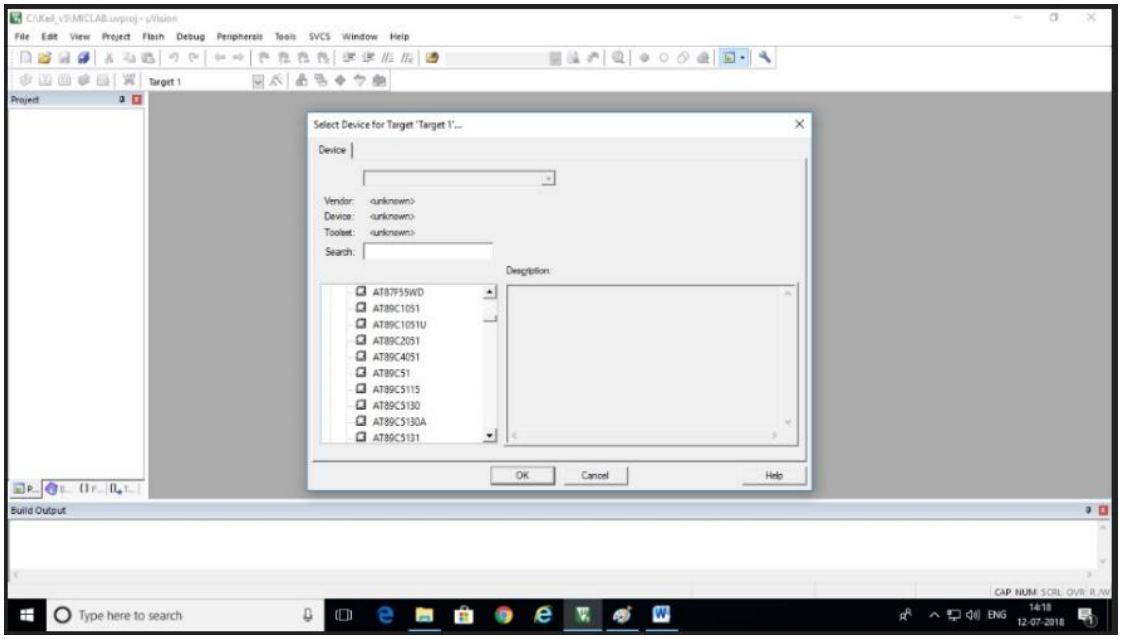
## IX. Procedure

**Steps for creating a project using Keil software**:

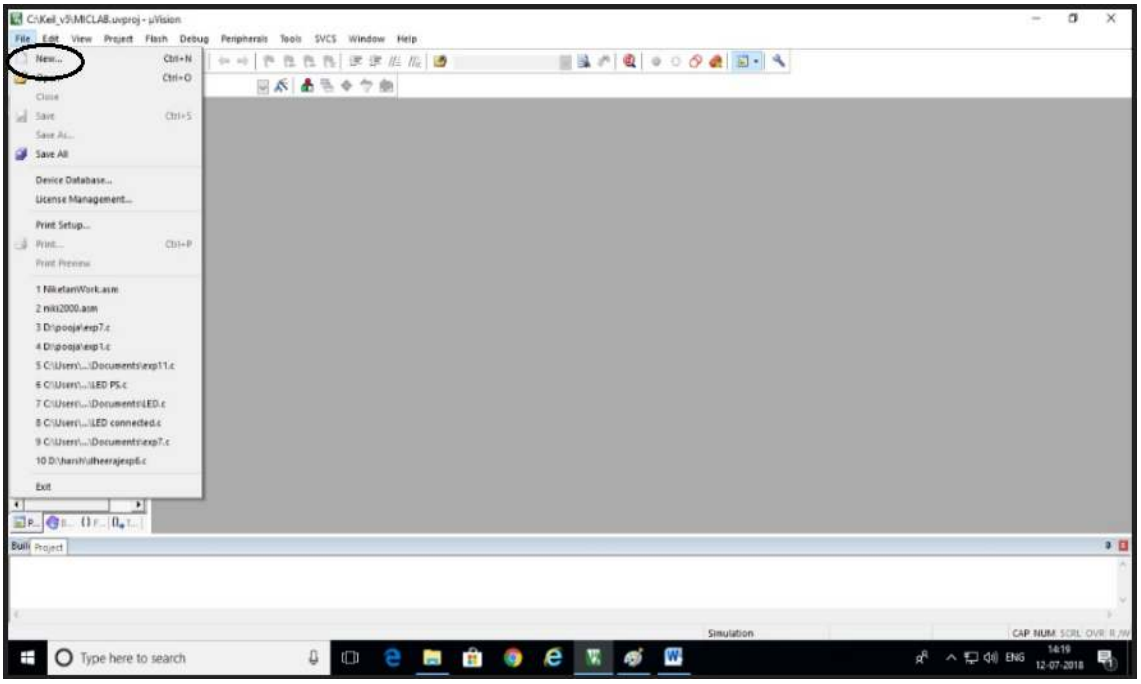
1. Start Keil by double clicking on Keil icon. (Keil automatically opens the last project which was opened previously, when Keil was closed).
2. To create new project, Click on Project and select new project.
3. Select appropriate location for new project and type project name, click on save button.



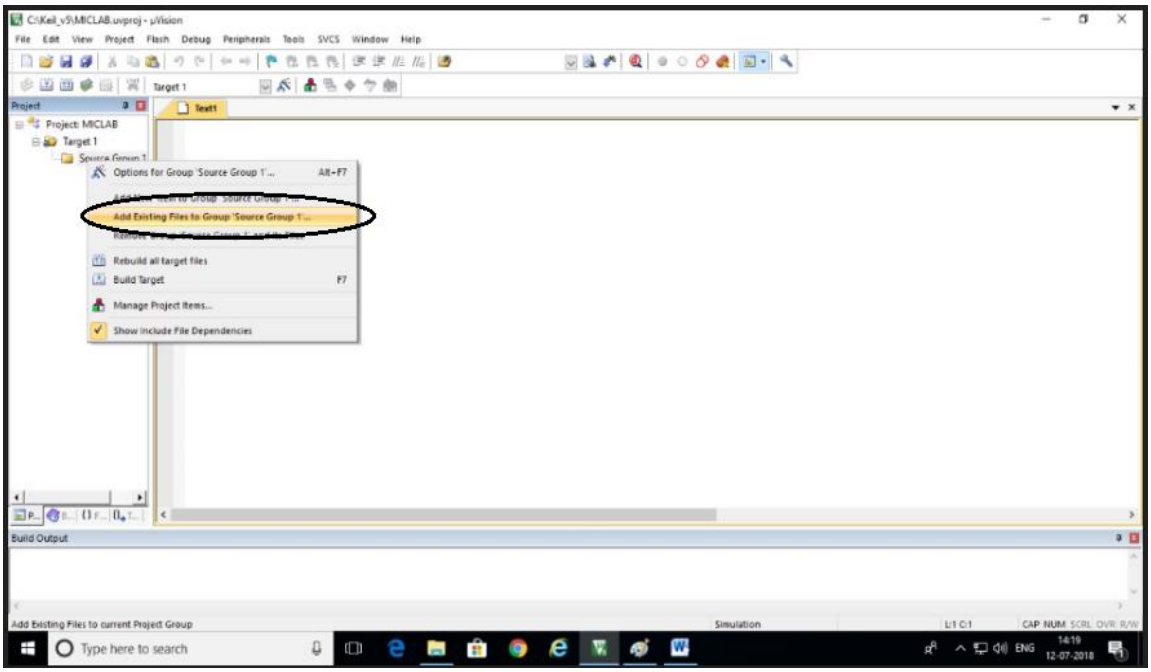

4. "Select device for Target Target-1" window will open. It displays a list of manufacturers of microcontrollers.
5. Double click on ATMEL or INTEL, list of supported microcontrollers gets displayed. Select 80C51AH from INTEL or AT89C51 (or as per the target board) for ATMEL then click ok.



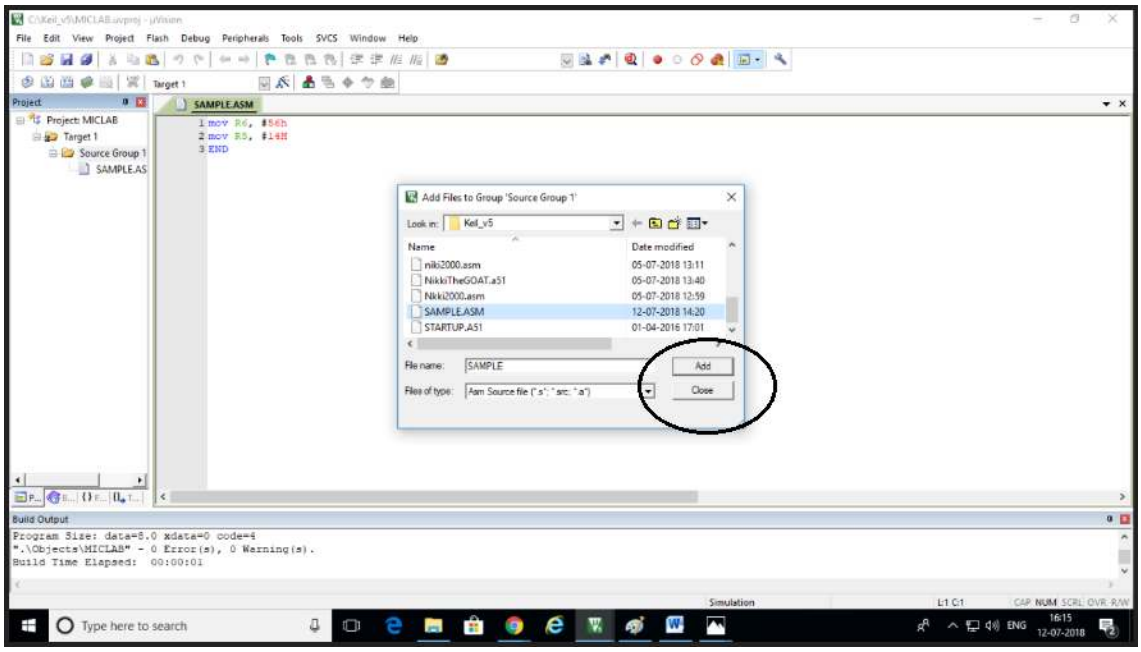

6. Click file pull down menu. Select new, a text editor window will open. Save this file in a same folder where project was stored. Give extension as .ASM or. A51.



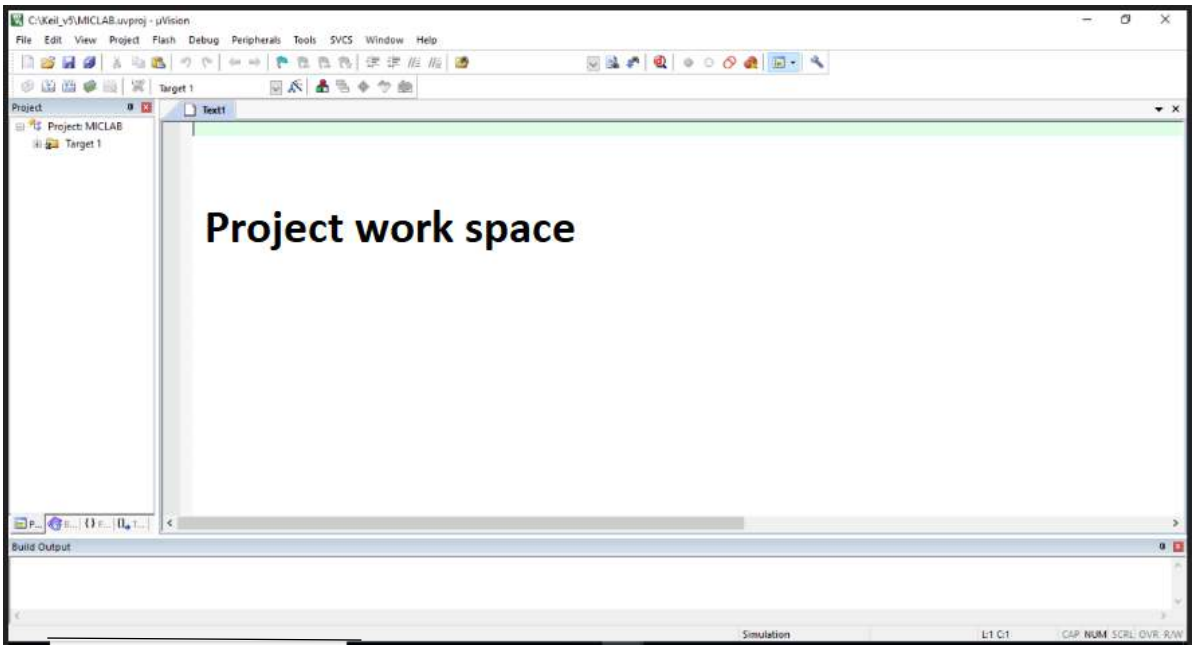

7. On left hand project work space window will display Target1 and Source group1.
8. Right click on source group; Add files to source group 1.



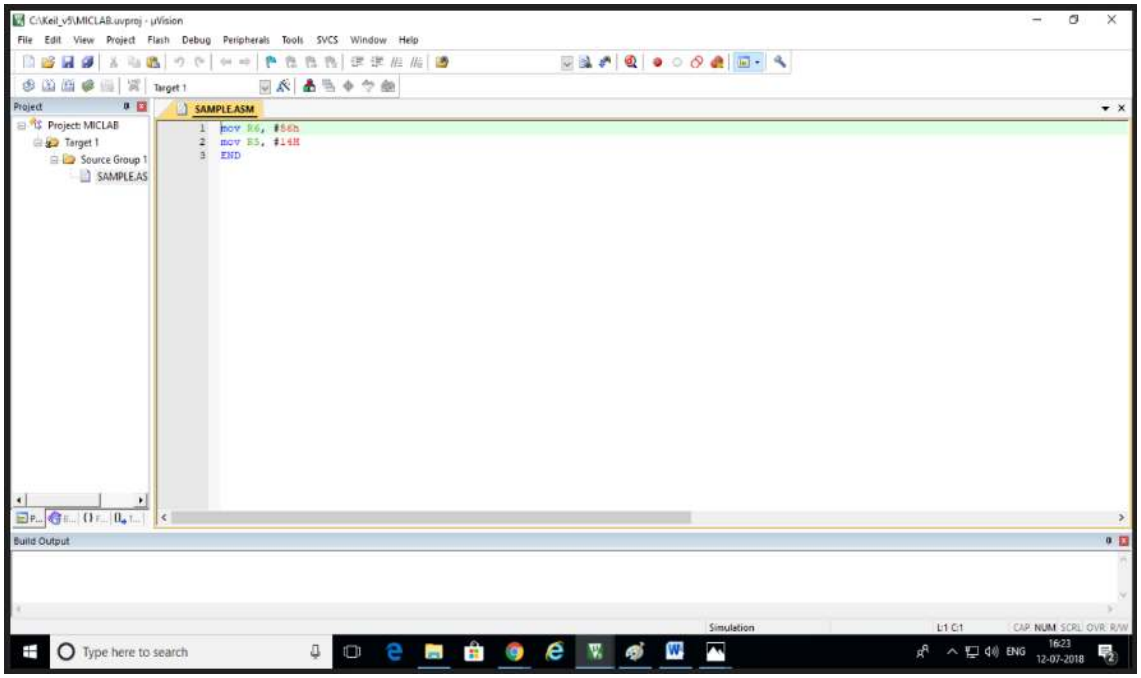

9. Select file type as asm source file. Now all .asm file names will be displayed. Select appropriate file, click ADD and close.



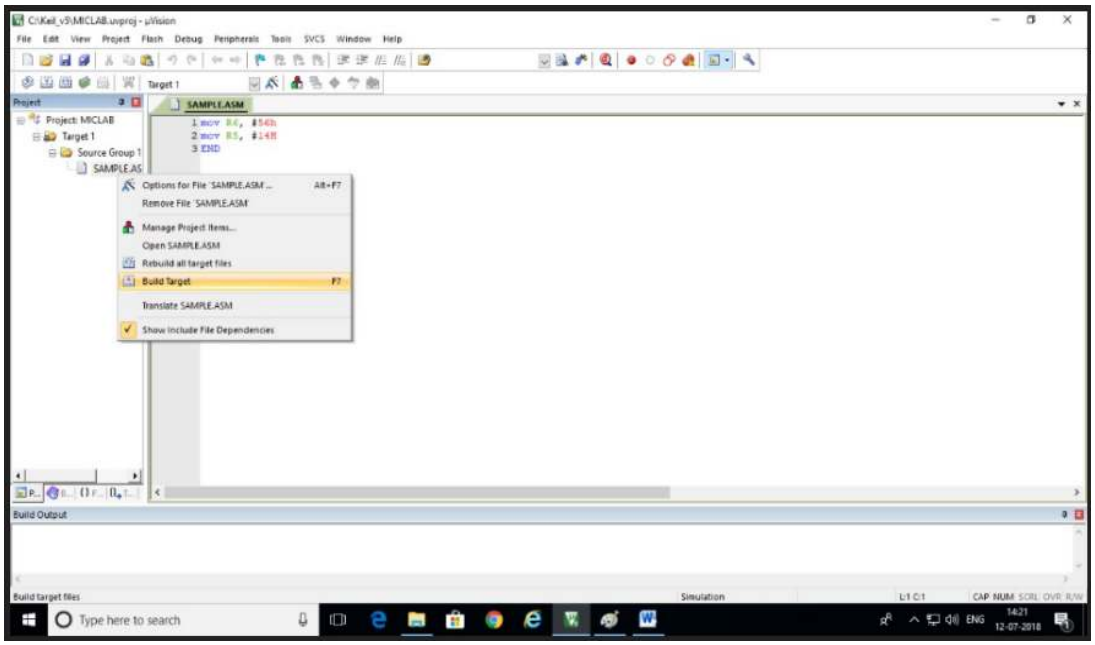

10. Project work space window will display ‘Target 1’ and ‘Source group 1’ with added file name.




11. Type assembly language program. End with END directive. Save the file periodically.




12. Right click on source group, click on Build target or press F7.

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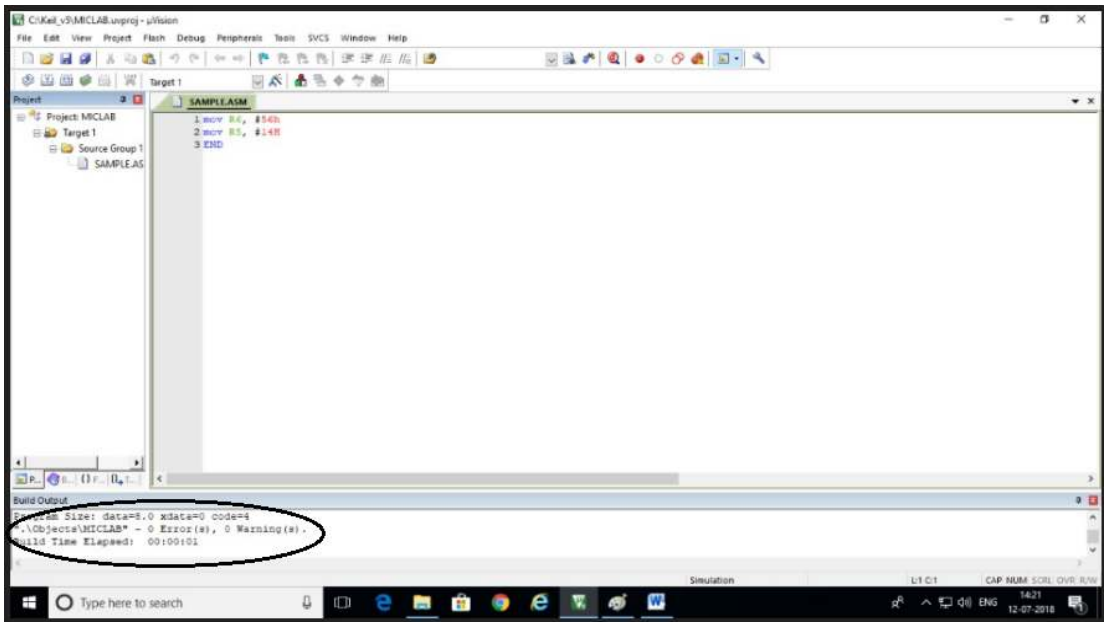
13. Output window will display the errors if any. If there are some errors, then remove the errors and repeat from step number 12 until no errors.

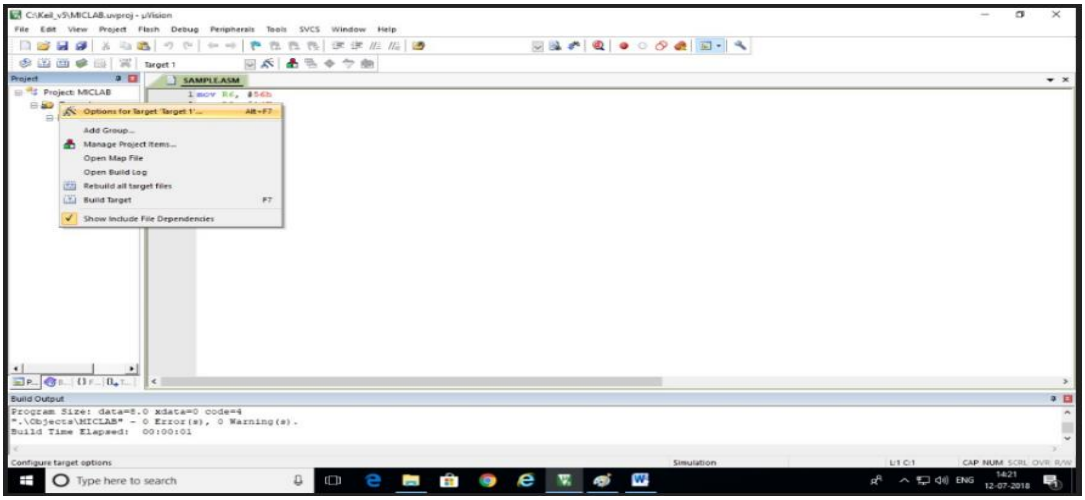


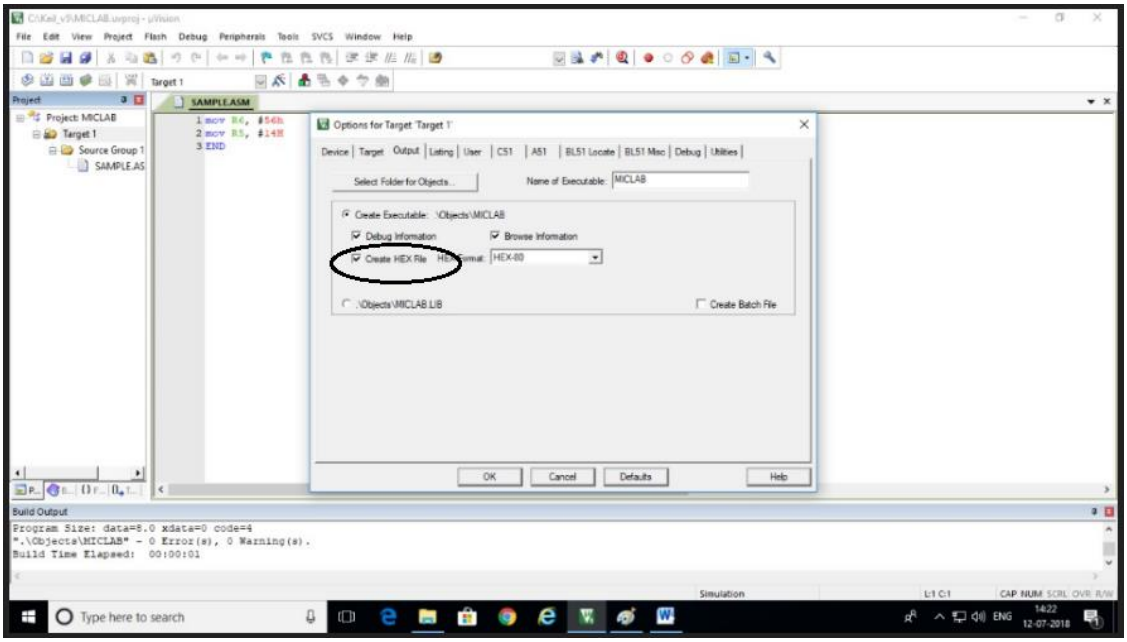
To create a hex file, follow this procedure

a. Right click on target in project window.
b. Click on options for target ‘target 1’.
c. Click on output tab and checkmark the option “create hex file”.
d. Click ok
e. Repeat step 12 again.

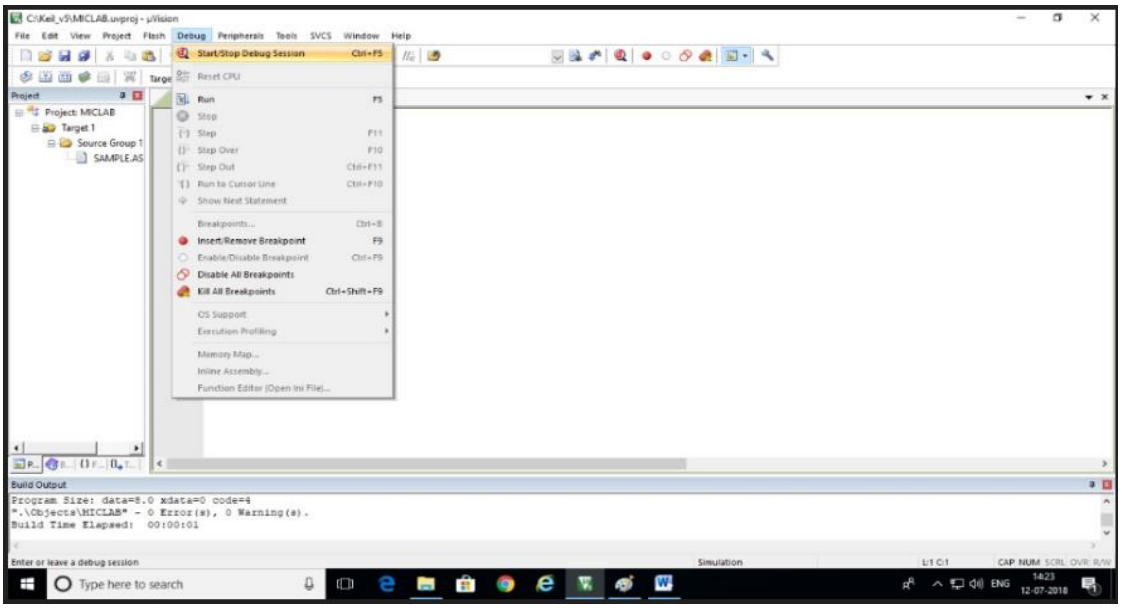
Observe output window. Hex file is created.

This step is optional for the experiments which need only simulation method to observe the results.



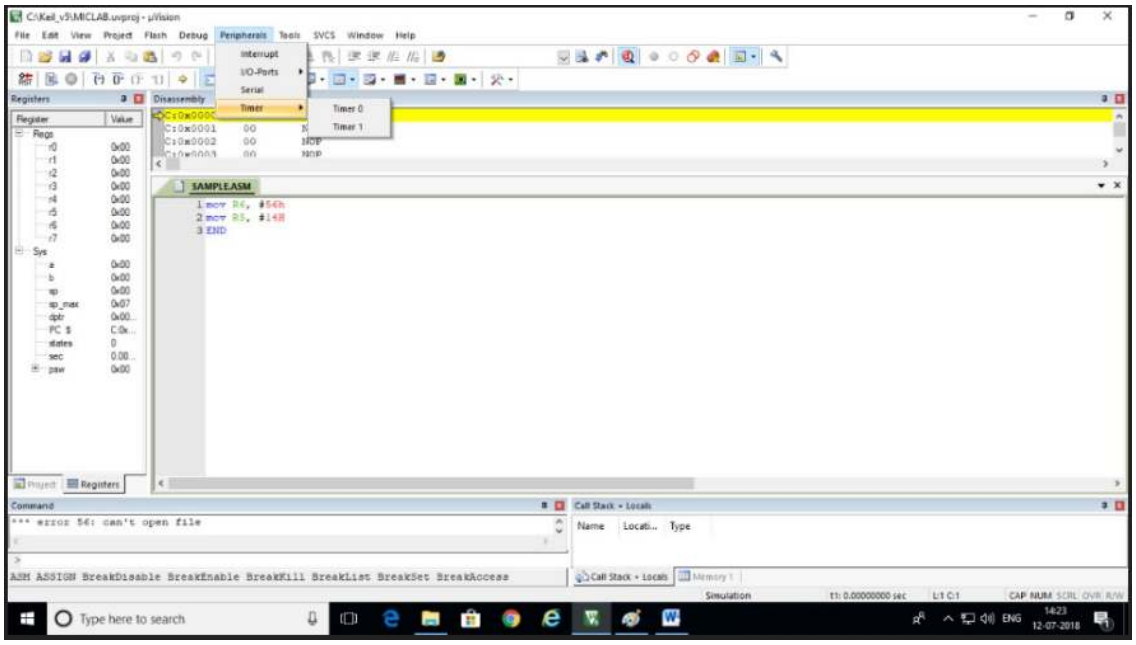



14. To start the simulation. Click on Debug pull down. Then select start/Stop debug session.




15. On start of debug session, project window will display all internal registers of 8051 and their contents. To execute the program step by step, go on clicking on “step over” button.
16. Observe the logic levels of port pins, timers, interrupt etc. by clicking on PERIPHERALS and select appropriate option.

Execute the program step by step and observe the logic levels on port pins.



17. Observe the serial communication by clicking VIEW pull down and select serial window-1 Option.

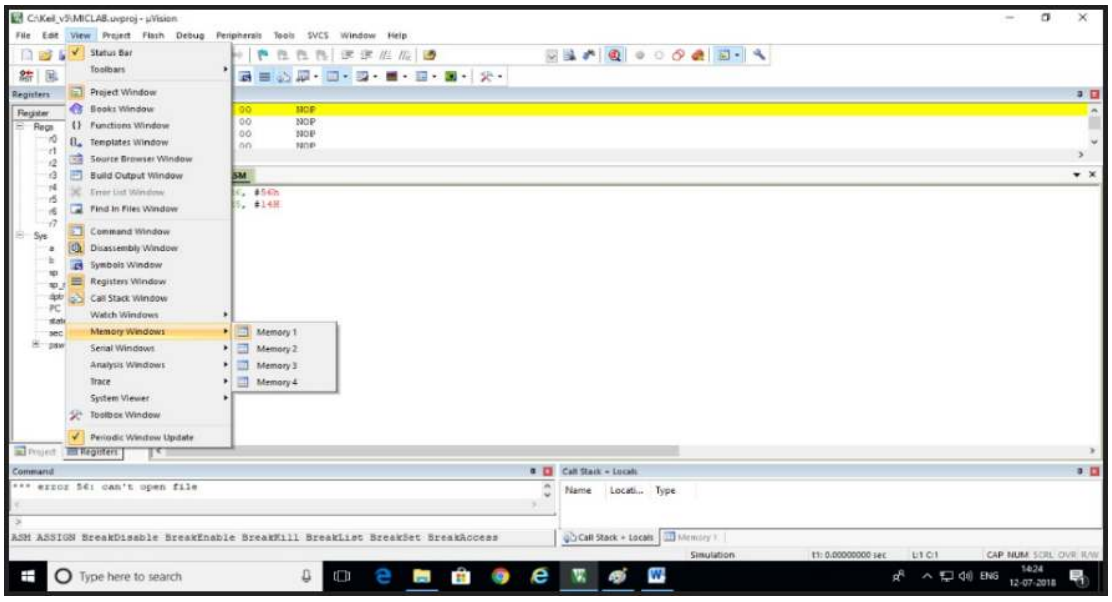
18. Observe the contents of internal, external and code memory contents.

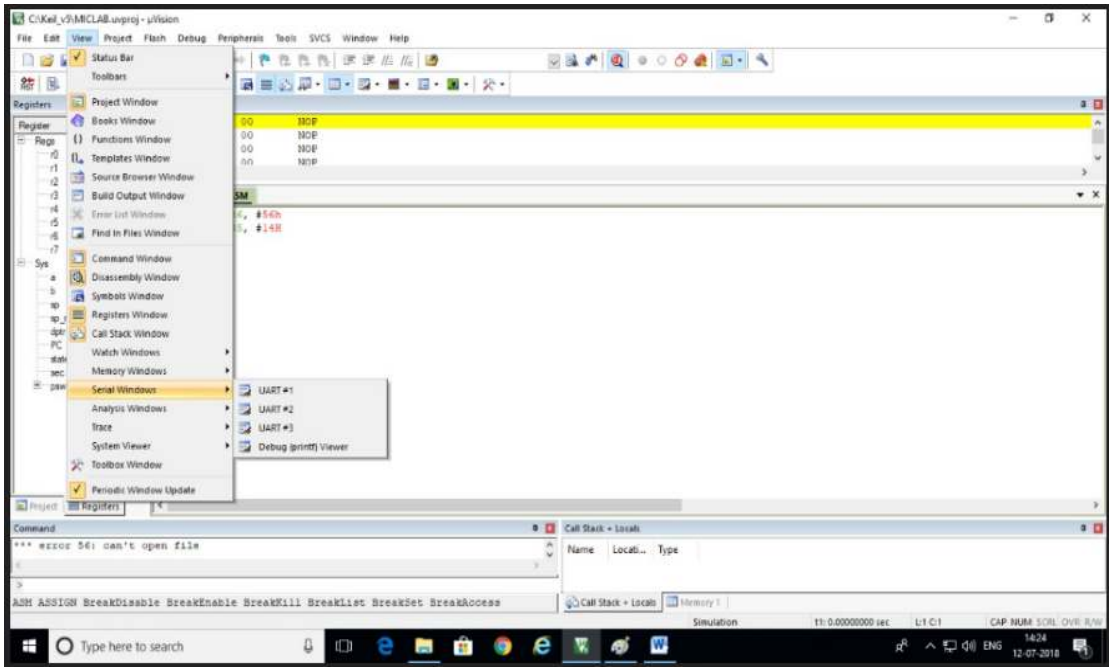
a. Click on memory window button

b. Memory window will get displayed near output window with address bar.

c. Type “i: address 8-bit H” for internal memory.” X: address16 bit H” for external memory for code memory type “C: address”.

d. To modify the contents of memory, right click on contents of any memory location and enter new valued to be loaded in that memory location






Please note that the features of Sr. no.16 to 18 are available only in debug mode

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

## X. Resources Used

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | | | |
| 2. | | | |

## XI. Actual procedure followed (use blank sheet provided if space is not sufficient)

1. ……
2. ……
3. ……
4. ……
5. ……

## XII. Observations

**Observe development board and list various components and write their functions.**

**Table no. 1**

| Sr. No. | Component | Function |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

## XIII. Result (Identification of various block of 8051 development board )

……

……

## XIV. Interpretation of Results (Hardware and software features of 8051 development board and Keil)

**……**

……

……

## XV. Conclusions and Recommendations (Actions/decisions to be taken based on the interpretation of results).

**……..……**

**……**

## XVI. Practical Related Questions

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO.***

1. Define bus. List different types of buses available in 8051 microcontroller
2. List any four features of Keil IDE.
3. State Program memory and Data memory capacity of 8051 microcontroller
4. Explain the selection criteria for selecting a microcontroller device.
5. State function of following pins of 8051 microcontroller:
   i) ALE ii) RST iii) $\overline{EA}$ iv) $\overline{PSEN}$

**(Space for answers)**

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## XVII. References / Suggestions for further Reading


1. https://www.ee.iitb.ac.in/uma/~wel/wel12/.../ATMEL%2089C51.pdf
2. https://ee.iust.ac.ir/files/ee/pages/az/mazidi.pdf
3. http://www.keil.com
4. http://www.circuitstoday.com/getting-started-with-keil-uvision

## XVIII. Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related(15 Marks)** | | **60% (15)** |
| 1 | Use of IDE tools for programming | 30% |
| 2 | Identifying components on developer kit | 20% |
| 3 | Follow ethical practices. | 10% |
| **Product related (10 Marks)** | | **40%(10)** |
| 4 | Observations and recording | 20% |
| 5 | Relevance of output of the problem definition. | 15% |
| 6 | Timely Submission of report, Answer to sample questions. | 05% |
| | **TOTAL** | **100% (25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No.2: Assembly Language Program using various addressing modes

**I Practical Significance**

The addressing modes specifies the way data can be moved or copied from source to destination location thus providing various options and flexibility for data transfer. This allows the programmer to write structured program which is essential to code maintainability.

**II Industry/Employer Expected Outcome(s)**

Maintain microcontroller based systems.

**III Course Level Learning Outcome(s)**

Develop program in 8051 in assembly language for the given operation.

**III Laboratory Learning Outcome(s)**

Develop an Assembly Language Program (ALP) for addition of two number bers using various addressing modes and assembler directives**.**

**V Relevant Affective Domain related outcome(s)**

Follow ethical practices.

**VI Relevant Theoretical Background**

**Addressing Modes**

A microcontroller provides various methods for accumulator essing data needed in the execution of an instruction. The various methods of accumulator essing the data are called addressing modes.

**1. Immediate addressing mode:**

The data is provided in instruction itself.

Ex: MOV A, #05H (The immediate data 05H provided in instruction is moved into A register).

Ex: ADD A, #05H (The immediate data 05H provided in instruction is added with contents of A register and the result is stored in A register).

**2. Register addressing mode:**

The registers hold the data. The permitted registers are A, R7-R0 of each register bank.

Ex: MOV A, R0 content of R0 register is copied into Accumulator.

Ex: ADD A, R0 content of R0 register is added with content of Accumulator and result is stored in Accumulator.

**3. Direct addressing mode:**

The data is in the RAM memory location and this address is given as part of instruction.

Ex: MOV A, 30H Content of RAM address 30H is copied into Accumulator.

Ex: ADD A, 40H Content of RAM address 40H is added with content of Accumulator and result is stored into Accumulator

4. **Register Indirect addressing mode:**
   Here the address of memory location is indirectly provided by a register.
   The '@' sign indicates that the register holds the address of memory location
   Ex: MOV A, @R0 Copy the content of memory location whose address is given in R0 register.
   Ex: ADD A, @R0 Add content of Accumulator and content of memory location whose address is given by register R0 and store the result in Accumulator.
5. **Register specific mode:**
   The operand is specified by certain specific registers such as accumulator or DPTR
   Ex: RRA Rotate the contents of accumulator to the right

6. **Indexed Addressing mode:**
   This addressing mode is basically used for accumulator addressing data from look up table. Here the address of memory is indexed.
   Ex: MOVC A, @A+DPTR The content of A register is added with content of DPTR and the resultant is the address of memory location from where the data is copied to A register.

**Assembler Directives:**

The assembler directives are instructions to the assembler to carry out certain activity during the assembly process. The common assembler directives are:

- ORG: Indicates the beginning of the address.
- DB: Used to define 8-bit data in decimal, binary, hexadecimal, ASCII formats.
- EQU: Used to define a constant without occupying a memory location.
- END**:** Indicates end of the source file.

## VII Required Resources/apparatus/equipment with specifications

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Desktop PC | Loaded with open-source IDE, simulation and program downloading software. | 1 No. |

## VIII Precautions to be followed

1) Check rules / syntax of assembly language programming.

## IX Procedure

**Develop Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL or INTEL and select 80c51AH or AT89C51.
5. Type the program in text editor and save as .asm or .a51.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window. It will display all internal registers of 8051 and their contents.
11. Note the contents of the registers in observation table

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**X Resources Used**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | | | |
| 2. | | | |

**SAMPLE PROGRAM 1:** Write a program to add two 8-bit numbers using immediate and direct addressing mode.

**Step 1: Algorithm**

1. Start
2. Move the immediate data 02H into accumulator
3. Add the data in accumulator with immediate data 03H
4. Initialize R1 with memory address 30H
5. Move the result of addition from accumulator to the memory address pointed by R1.
6. Stop

**Step 2-Flowchart**

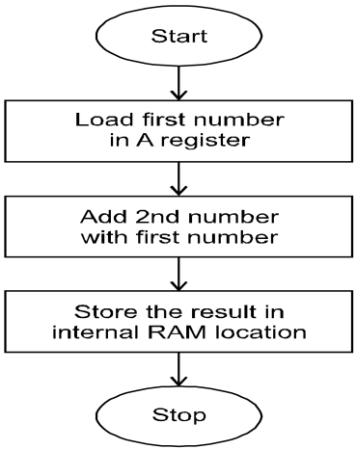


**Fig 2.1 Flowchart to add data from accumulator with immediate data**

**Step 3: Assembly Language Program**

| Memory Address | Hex Code | | Label | Mnemonics | Comments |
|---|---|---|---|---|---|
| | | | | ORG 0000H | |
| C:0x0000 | 7402 | | | MOV A, #02H | ;Move the data 02H in accumulator |
| C:0x0002 | 2403 | | | ADD A, #03H | ;Add the contents of accumulator with 03H |
| C:0x0004 | F530 | | | MOV 30H, A | ;Move the result in accumulator to memory address 30H |
| | | | | END | ;Stop |

**Output Window**

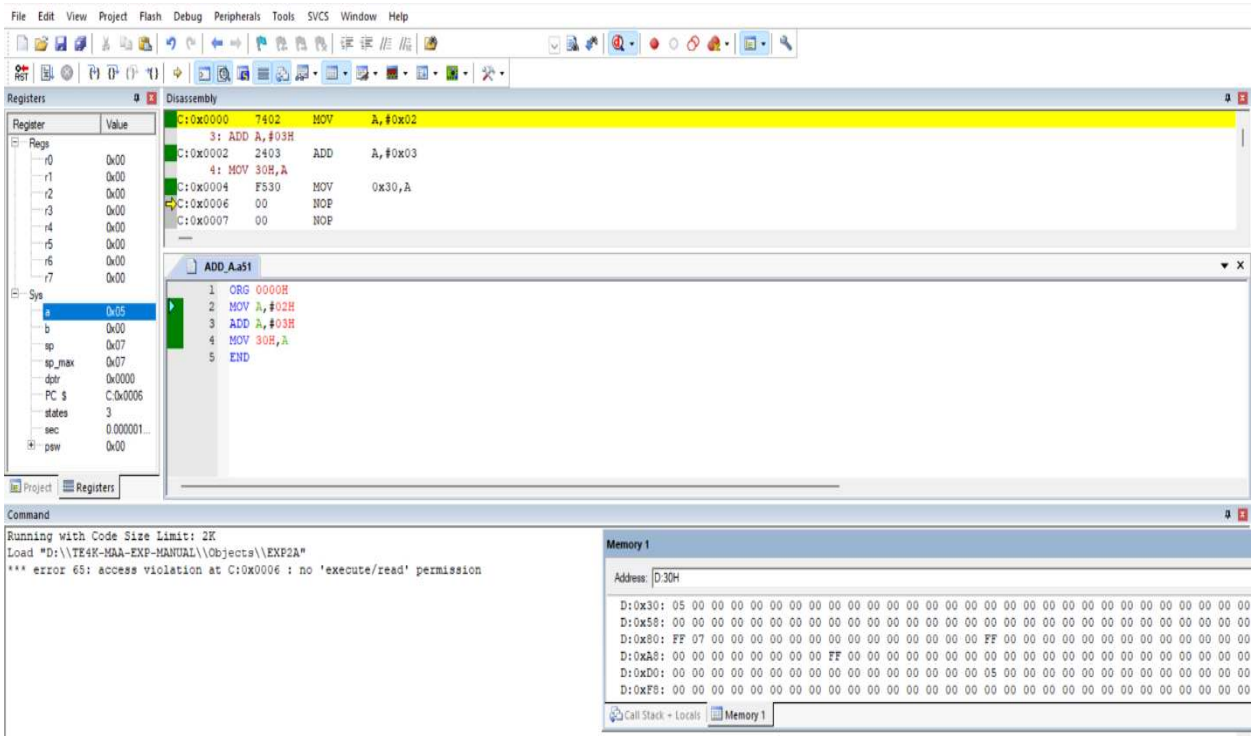


**Fig 2.2 Output Window**

**SAMPLE PROGRAM 2:** Write a program using ORG, DB and END directives

**Step 1-Algorithm**

1. Start.
2. Use ORG directive to set memory location at 0000H.
3. Initialize data pointer to memory location pointed by label MYDATA.

4. Clear Accumulator.
5. Move into accumulator a byte of data located at address pointed by DPTR.
6. Move data in accumulator to register r0
7. Increment data pointer
8. Clear Accumulator.
9. Move into accumulator a byte of data located at address pointed by DPTR.
10. Add data in accumulator with data in register R0
11. Initialize Data pointer to new memory location 2000H.
12. Move the contents of Accumulator to address pointed by DPTR.
13. Use data directive to write data 02H at memory location 0010H and data 03H at memory location 0011H

**Step 2-Flowchart**

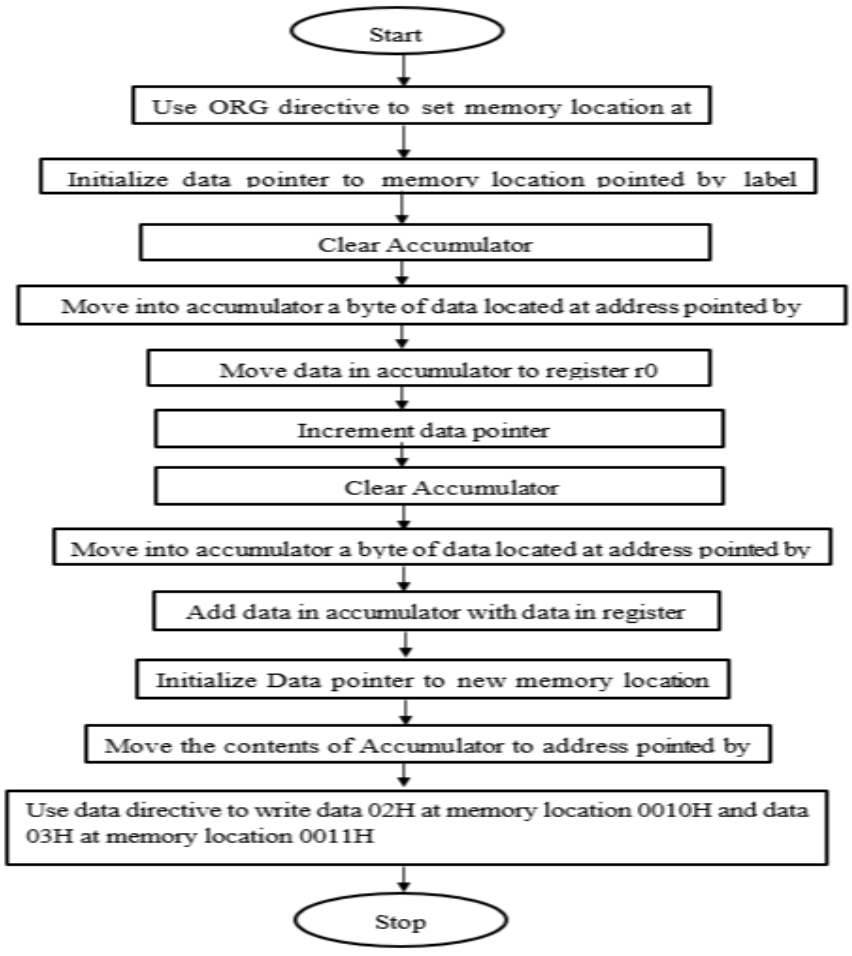


**Fig 2.3 Flowchart for ORG, DB and END directives program**

**Step 3: Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | ;Use ORG directive to set memory location at 0000H |
| 0000 | 900010 | | MOV DPTR, #MYDATA | ;Initialize data pointer to memory Location pointed by label MYDATA |
| 0003 | E4 | | CLR A | ; Clear Accumulator |
| 0004 | 93 | | MOVC A, @A+DPTR | ;Move code byte at ACCUMULATOR +DPTR to ACCUMULATOR |
| 0005 | F8 | | MOV R0, A | ;Move data in accumulator to register R0 |
| 0006 | A3 | | INC DPTR | ;Increment data pointer by1 |
| 0007 | E4 | | CLR A | ; Clear Accumulator |
| 0008 | 93 | | MOVC A, @A+DPTR | ;Move code byte at accumulator +DPTR to accumulator |
| 0009 | 28 | | ADD A, R0 | ;Add data in accumulator with data in Register R0 |
| 000A | 902000 | | MOV DPTR, #2000H | ;Initialize data pointer to new data memory location 2000H |
| 000D | F0 | | MOVX @DPTR, A | Move the contents of accumulator to address pointed by DPTR |
| 000E | 80FE | | SJMP $ | |
| 0010 | 0203 | MYDATA: | DB 02H,03H | ;8-bit Data bytes to be added |
| | | | END | ;Stop |

## Output Window

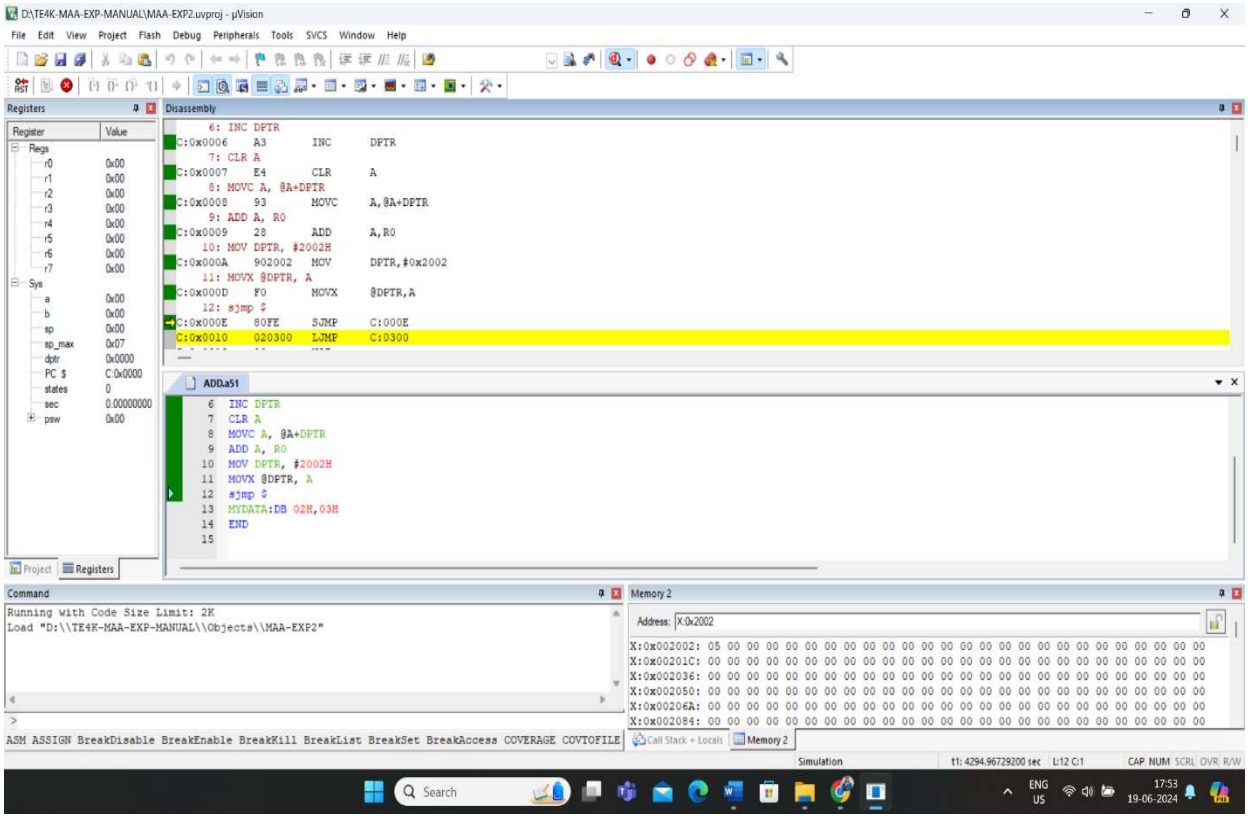


**Fig 2.4 Output Window**

**Problem statement #1 for student:** Write a program to add two data bytes stored in internal RAM locations using direct and indirect addressing Mode.

| Step 1-Algorithm | Step 2-Flowchart |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
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**Problem statement #2 for student:** Write a program using EQU directive.

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
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## X Resources used

| Sr. No. | Name of Resource | Specifications | Quantity |
|---|---|---|---|
| | | | |
| | | | |

## XI Actual Procedure Followed (use blank sheet provided if space not sufficient)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……
9. ……

## XII Observation Table

After execution of sample program 1

| | |
|---|---|
| Accumulator | |
| Immediate data | |
| 30H memory location | |

After execution of sample program 2

| | |
|---|---|
| Accumulator | |
| R0 | |
| 2000H memory location | |

## XIII Results (Output of the Program)

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## XIV Interpretation of Results (Give meaning of the above obtained results)

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**XV Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

……..……

…..……..……

**XVI Practical related questions**

**Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.**

1. State significance of the symbol # used in addressing mode.
2. Develop a program to add two data bytes 25H and data 42H using immediate and register addressing mode
3. Interpret output of following program

```
ORG 0000H
DATA1  EQU 05
DATA2  EQU 02
MOV A, #DATA1
MOV R2, #DATA2
ADD A, R2
END
```

**[Space for Answers]**

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## XVII References/Suggestions for further reading


1. The 8051 Microcontroller and Embedded system Using Assembly and C- Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. Mckinlay- Pearson /Prentice Hall, , 2nd edition, Delhi,2008, ISBN 978-8177589030
2. https://nptel.ac.in/courses/Webcourse-contents/IISc-BANG/Microprocessors%20and%20Microcontrollers/pdf/Teacher_Slides/mod2/M2L2.pdf
3. https://nptel.ac.in/courses/Webcourse-contents/IIT KANPUR/microcontrollers/chap2.pdf
4. https://www.youtube.com/watch?v=nlT5B3JEAak


## XVIII Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 3: ALP to perform arithmetic operations on 8- bit data

## I Practical Significance

Applications of microcontroller often involve performing mathematical calculations. 8051 microcontroller provide arithmetic instructions for performing operations such as addition, subtraction, multiplication, division etc. This practical will help the students to develop skills to write assembly program for arithmetic operations.

## IV Industry/Employer Expected Outcome(s)

Maintain microcontroller-based systems.

## III Course Level Learning Outcome(s)

Develop program in 8051 in assembly language for the given operation.

## V Laboratory Learning Outcome(s)

Develop an ALP to perform arithmetic operations: addition, subtraction, multiplication and division on 8-bit data

## V Relevant Affective Domain related outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

Arithmetic operations of addition, subtraction, multiplication and division are carried out by Register A. Register B is specifically used for multiplication and division purpose. The 8051 microcontroller consists of four register banks, Bank0, Bank1, Bank2, Bank3. Each bank contains 8 registers (R0 to R7).

Arithmetic operations affect flags in PSW register of 8051

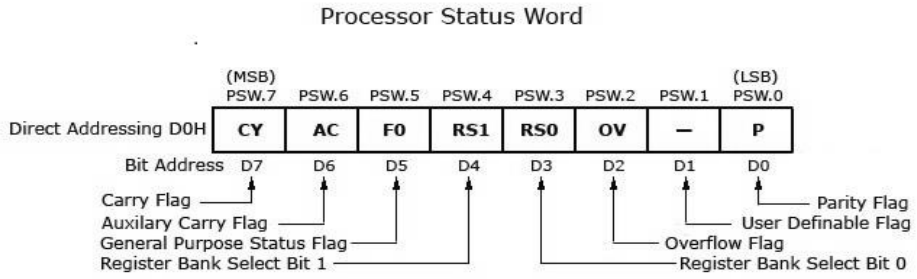


**Fig 3.2 Program Status Word Register**

**Arithmetic Instructions:**

| **Mnemonics** | **Operational description** |
|---|---|
| ADD A, #number | Add the immediate number with accumulator and stores result in accumulator |
| ADD A, Rn | Add the data in Rn with accumulator and stores result in accumulator |
| ADD A, add | Add the data in add with accumulator and stores result in accumulator |
| ADD A, @Rp | Add the data at the address in Rp with accumulator and stores result in accumulator |
| ADDC A,# number | Add the immediate number with accumulator and carry, stores result in accumulator |
| ADDC A, Rn | Add the data in Rn with accumulator and carry, stores result in accumulator |
| ADDC A, add | Add the data in add with accumulator and carry, stores result in accumulator |
| ADDC A, @Rp | Add the data at the address in Rp with accumulator and carry, stores result in accumulator |
| SUBB A, #number | Subtract immediate number and carry from accumulator; stores the result in accumulator |
| SUBB A, add | Subtract the content of add and carry from accumulator; stores the result in accumulator |
| SUBB A, Rn | Subtract the data in Rn and carry from accumulator; stores the result in accumulator |
| SUBB A, @Rp | Subtract the data at the address in Rp and carry from accumulator; stores the result in accumulator |
| MUL AB | Multiply accumulator and register B. store the lower byte of result in accumulator and higher byte in B |
| DIV AB | Divide accumulator by register B. store quotient in accumulator and remainder in B |
| INC A | Increments the accumulator by 1 |
| INC Rn | Increments the data in register Rn by 1 |

| | |
|---|---|
| INC @Rp | Increments the data at the address in Rp |
| DEC A | Decrements the accumulator by 1 |
| DEC Rn | Decrements the data in register Rn by 1 |
| DEC @Rp | Decrements the data at the address in Rp |
| INC DPTR | Increments data pointer by 1 |

## XII Required Resources/apparatus/equipment with specifications

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Desktop PC | Loaded with open-source IDE, simulation and program downloading software. | 1 No. |

## XIII Precautions to be followed

1) Check rules / syntax of assembly language programming.

## XIV Procedure

**Develop Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL or INTEL and select 80c51AH or AT89C51.
5. Type the program in text editor and save as .asm or .a51.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window. It will display all internal registers of 8051 and their contents.
11. Note the contents of the registers in observation table

## E-Waste Management

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1:** Write a program to add, subtract, multiply and divide two 8 bit numbers.

**Step 1: Algorithm**

1. Move data 04H in Accumulator.
2. Add data 03H to the number stored in accumulator (04 H).
3. Store result of addition operation in register R1
4. Clear Carry flag
5. Move data 08H in accumulator.
6. Subtract data 02H from number stored in accumulator (08 H).
7. Store result of subtraction operation in register R2
8. Move data 05H in accumulator and data 03H in register B.
9. Multiply the two number.
10. Store lower byte of product in R3 and higher byte of product R4.
11. Move data 10 H in Accumulator and 06 H in register B.
12. Divide the two number.
13. Store quotient in register R5 and remainder in register R6
14. Stop

**Step 2-Flowchart**

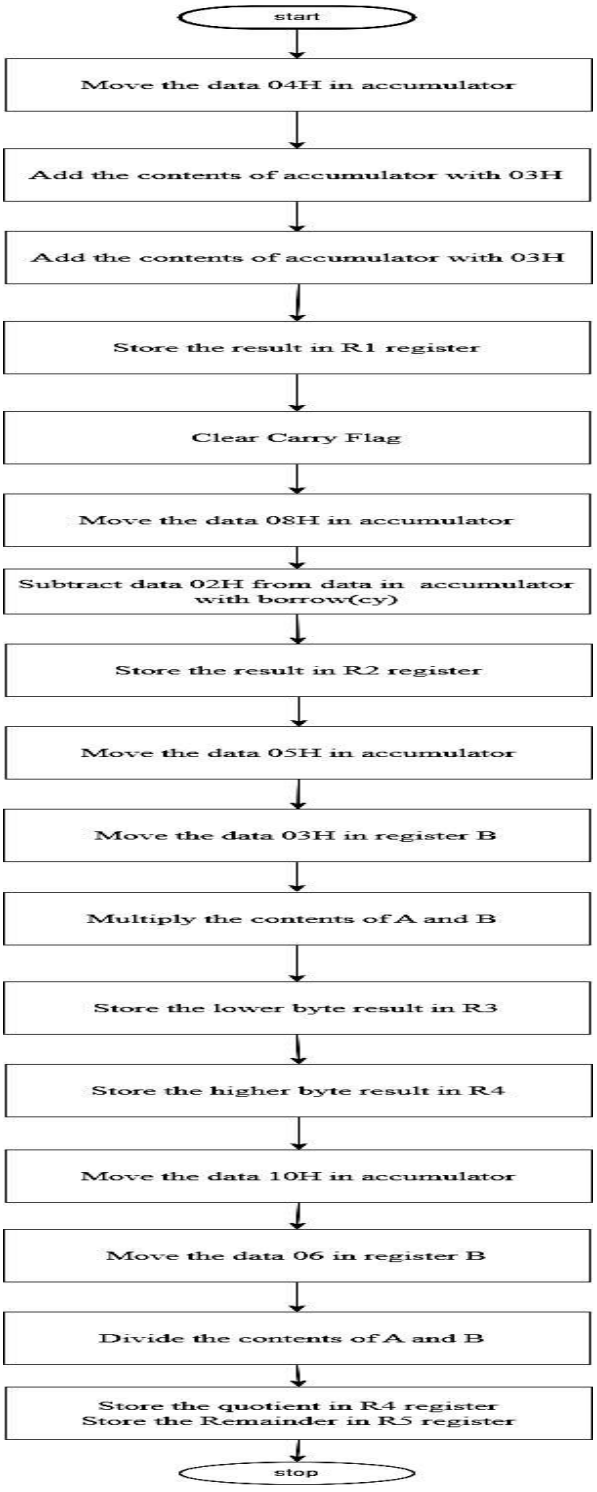


**Fig 3.3 Flowchart for arithmetic operations**

### Step 3: Assembly Language Program

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | |
| C:0x0000 | 7404 | | MOV A, #04H | ; Move the data 04H in accumulator |
| C:0x0002 | 2403 | | ADD A, #03H | ; Add the contents of accumulator with 03H |
| C:0x0004 | F9 | | MOV R1, A | ; Store the result in R1 register |
| C:0x0005 | C3 | | CLR C | ;Clear the carry flag |
| C:0x0006 | 7408 | | MOV A, #08H | ;Move the data 08H in accumulator |
| C:0x0008 | 9402 | | SUBB A, #02H | ;Subtract the 02H from data in accumulator with borrow(cy) |
| C:0x000A | FA | | MOV R2, A | ;Store the result in R2 register |
| C:0x000B | 7405 | | MOV A, #05H | ;Move the data 05H in accumulator |
| C:0x000D | 75F003 | | MOV B, #03H | ;Move the data 03H in register B |
| C:0x0010 | A4 | | MUL AB | ;Multiply the contents of A and B |
| C:0x0011 | FB | | MOV R3, A | ;Store the lower byte result in R3 |
| C:0x0012 | ACF0 | | MOV R4, B | ;Store the higher byte result in R4 |
| C:0x0014 | 7410 | | MOV A, #10H | ;Move the data 10H in accumulator |
| C:0x0016 | 75F006 | | MOV B, #06H | ;Move the data 06 in register B |
| C:0x0019 | 84 | | DIV AB | ;Divide the contents of A and B |
| C:0x001A | FD | | MOV R4, A | ;Store the quotient in R4 register |
| C:0x001B | AEF0 | | MOV R5, B | ;Store the Remainder in R5 register |
| | | | END | ;Stop |

### Output Window

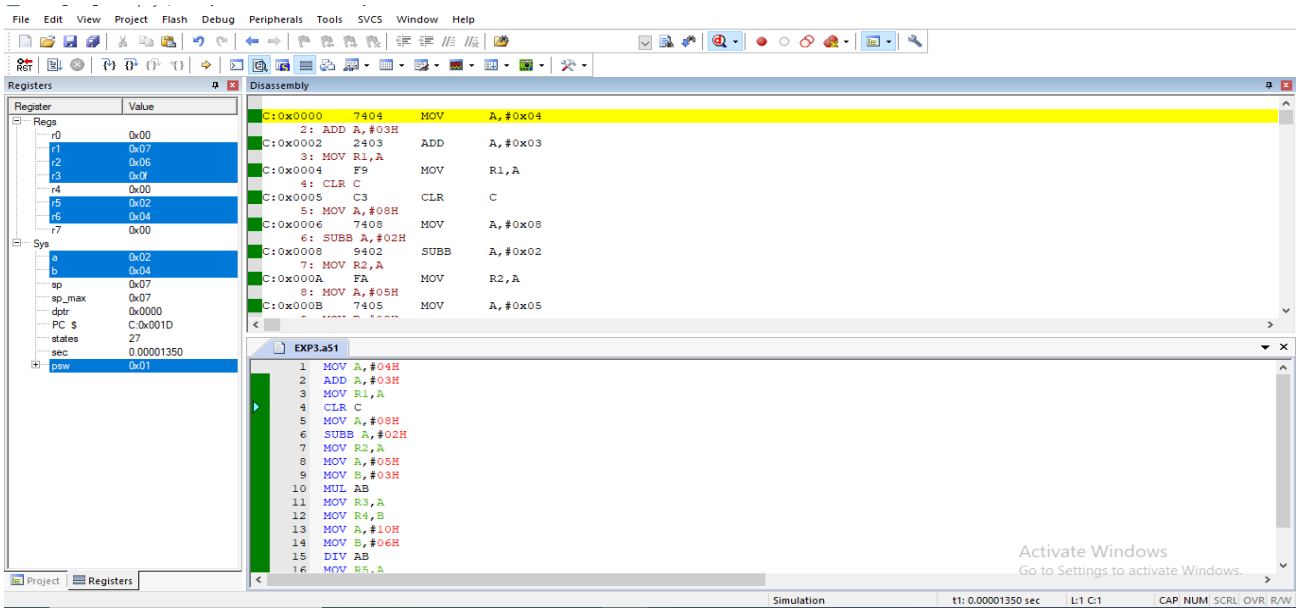


**Fig 3.4 Output Window**

**Problem statement for student:** Write a program to perform multiplication and division of two 8 bit numbers taken from external memory locations and store the result in Registers R0 to R3.

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
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**XV Resources used**

| Sr. No. | Name of Resource | Specifications | Quantity |
|---|---|---|---|
| | | | |
| | | | |

**XVI Actual Procedure Followed** (use blank sheet provided if space not sufficient**)**

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2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……

**XII Observations for sample program** (use blank sheet provided if space not sufficient)

| Arithmetic operation | DATA BYTE1 | DATA BYTE 2 | Result after execution |
|---|---|---|---|
| Addition | | | **R1 =** |
| Subtraction | | | **R2 =** |
| Multiplication | | | **R3 =** **R4 =** |
| Division | | | **R5 =** **R6 =** |

**XIII Results (Output of the Program)**

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**XIV Interpretation of Results (Give meaning of the above obtained results)**

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**XV Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

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**XVI Practical related questions**

***Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.***

1. Write an ALP to subtract series of 5 numbers.
2. State the flags affected by DIV AB instruction.
3. Interpret the output of following program
   MOV A, # 255
   INC A
   END
4. Give the status of CY, AC, P flag after execution of following program:
   MOV A, # 78H
   ADD A, # 55H
   END

**[Space for Answers]**

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## XVII References/Suggestions for further reading


1. https://www.tutorialspoint.com/arithmetic-group-in-8051
2. https://technobyte.org/arithmetic-instructions-8051/
3. https://technobyte.org/arithmetic-instructions-8051/


## XVIII Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 4: ALP to perform arithmetic operations on 16-bit data.

## I Practical Significance

8051 microcontrollers have single instruction arithmetic operations. Applications such as BCD and ASCII conversions and checksum byte testing require arithmetic operations. This practical will help the students to develop skills to write assembly program for arithmetic operations.

## II Industry/Employer expected outcome(s)

**Maintain microcontroller-based systems.**

### III Course Level Learning Outcome(s)

Develop program in 8051in assembly language for the given operation.

## IV Laboratory Learning Outcome(s)

Develop an ALP to perform arithmetic operations: addition, subtraction on 16-bit data.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

When performing 16-bit addition on an 8051 microcontroller, you typically use a combination of registers to store the intermediate values, operands, and results. The registers used for 16-bit arithmetic operations are:

1. Accumulator (A): Used for arithmetic and logical operations.
2. Data Pointer (DPTR): A 16-bit register used to point to memory locations. Often used to point to the locations of the operands in memory.
3. General-Purpose Registers (R0 - R7): Used to store data temporarily.

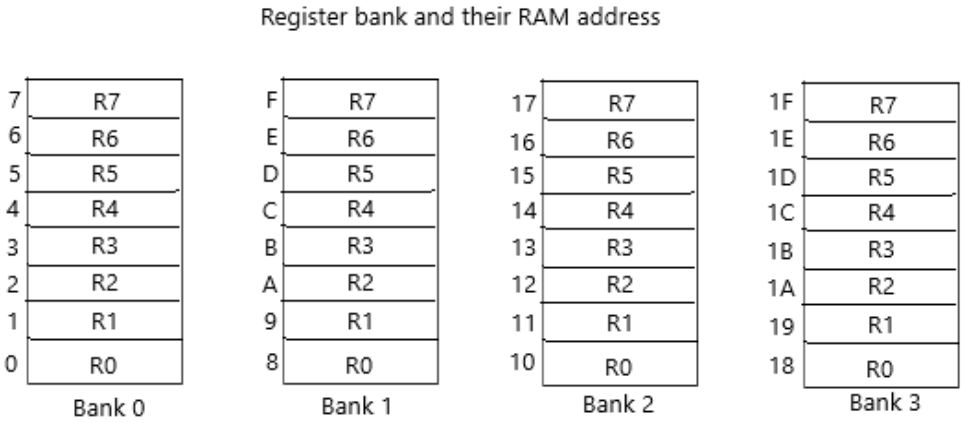


**Fig 4.1 Register Banks**

8051 uses DPTR, a 16 bit register to access the 16-bit data from external memory. It is used in MOVX, MOVC command
Arithmetic operations affect flags in PSW register of 8051

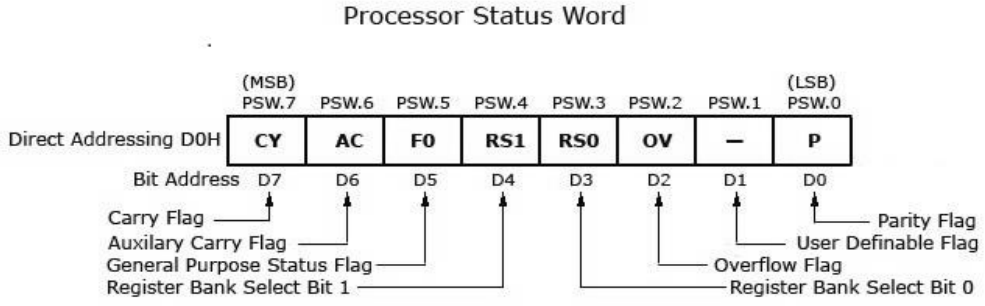


**Fig 4.2 Program Status Word Register**

The 8051 microcontroller supports various arithmetic operations using specific instructions. Here's an overview of the key instructions used for arithmetic operations:

**Addition Instructions**
**ADD A, source:** Adds the source operand to the accumulator (A). Source can be a register (R0-R7), a direct address, or an immediate value.
Example: ADD A, R1: Adds the value in register R1 to the accumulator

**ADDC A, source:** Adds the source operand to the accumulator along with the carry bit. Used for multi-byte (e.g., 16-bit) addition where carry needs to be considered.
Example: ADDC A, R2: Adds the value in register R2 and the carry bit to the accumulator

**Subtraction Instructions**
SUBB A, source: Subtracts the source operand and the carry bit from the accumulator. Source can be a register, a direct address, or an immediate value.
Example: SUBB A, #10H: Subtracts the immediate value 10H and the carry bit from the accumulator

## VII Resources Required

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1 | Desktop PC | Loaded with open-source IDE, simulation and program downloading software | 1 No. |

## VIII Precautions to be Followed

1. Check rules / syntax of assembly programming.

## IX Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL and select AT89C51.
5. Type the program in text editor and save as filename.asm extension.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window.
11. Note the values of the result of various operations in the observation table.

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: To perform following: arithmetic operations: 16-bit addition

**Step 1-Algorithm**

1. Select register bank 2.
2. Initialize Carry Counter to get result > 16 bit.
3. Load LSB of first number in Accumulator.
4. Add LSB of Second number with LSB of first number.
5. Store LSB of result.
6. Load MSB of first number in Accumulator.
7. Add MSB of second number with MSB of first Number.
8. If Carry is not 1, then go to step 10.
9. Increment Carry Counter by 1.
10. Store MSB of result.
11. Store Carry of result.
12. Stop.

**Step 2-Flow Chart**

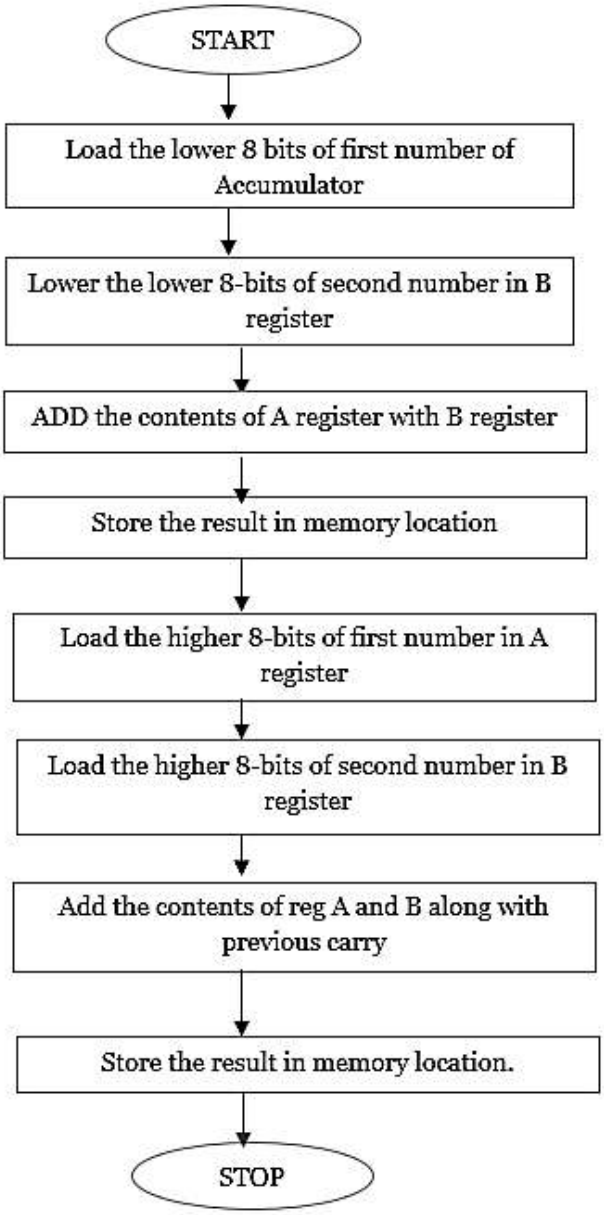


**Fig 4.3 Flowchart for arithmetic operations**

**Step 3- Assembly Language Sample Program: 16-bit Addition**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | |
| C:0x0000 | E540 | | MOV A, 40H | Load the contents of memory location 40H in A register (Lower 8-bits of first number) |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x0002 | 8542F0 | | MOV B, 42H | Load the contents of memory location 42H in B register (Lower 8 bits of second number) |
| C:0x0005 | 25F0 | | ADD A, B | Add the contents of A and B |
| C:0x0007 | F544 | | MOV 44H, A | Store the result in memory location 44H |
| C:0x0009 | E541 | | MOV A, 41H | Load the content of 41H in register A (Higher 8 bits of first number) |
| C:0x000B | 8543F0 | | MOV B, 43H | Load the contents of 43H in register B (Higher 8 bits of second number) |
| C:0x000E | 35F0 | | ADDC A,B | ADD the contents of A and B with previous carry |
| C:0x0010 | F545 | | MOV 45H, A | Store the result at location 45H |
| | | | END | |

**Output Window**

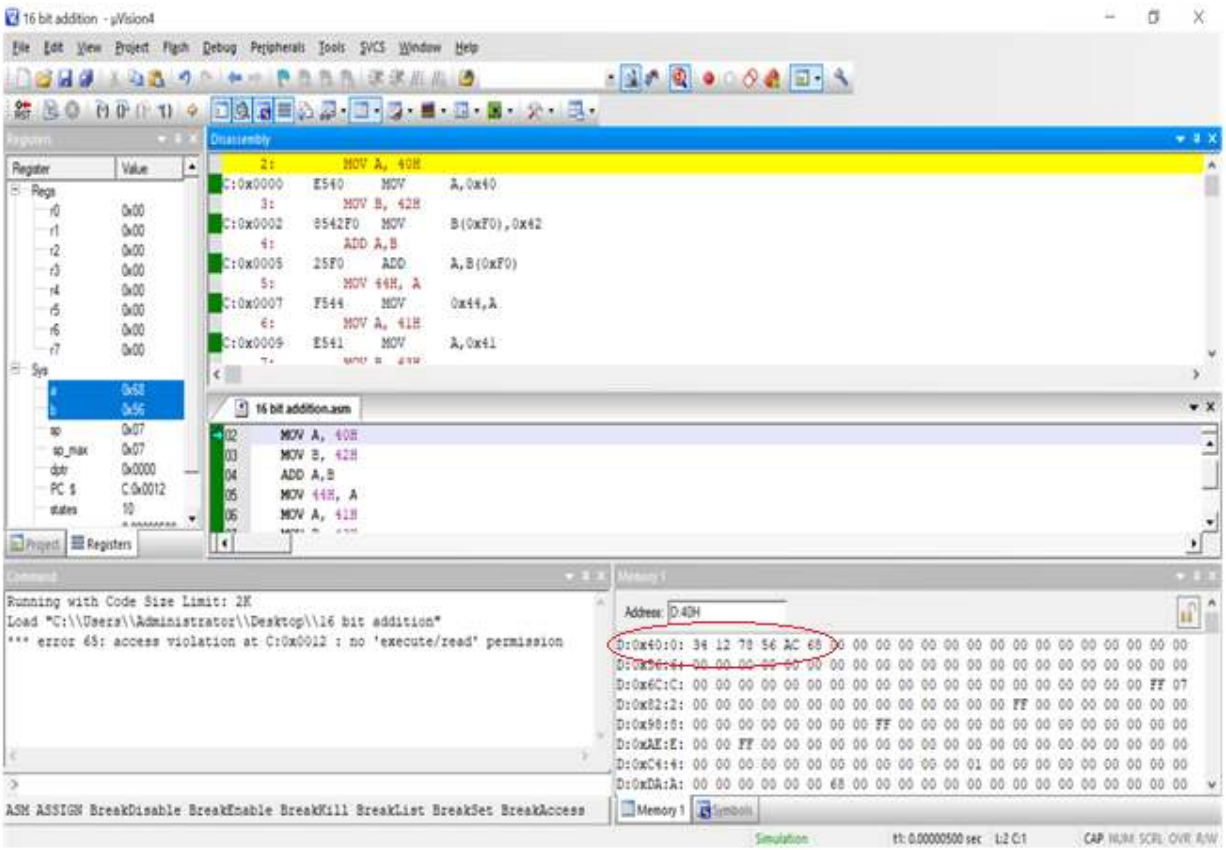


**Fig 4.4 Output Window**

**Problem statement 1 for student**: Write a program to perform 16-bit subtraction

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
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| Memory Address | Hex Code | Label | Mnemonics | Comments |
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**X Resources Used**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| | | | |

**XI Actual Procedure Followed** (use blank sheet provided if space not sufficient)

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**XII Observations for sample program** (use blank sheet provided if space not sufficient)

| Sr. No. | Registers/Memory Locations used in the code | Contents / Result after execution |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |

| Sr. No. | Registers/Memory Locations used in the code | Contents / Result after execution |
|---|---|---|
| 4 | | |
| 5 | | |
| 6 | | |

**XIII Results** (Output of the Program)

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**XIV Interpretation of Results (**Give meaning of the above obtained results)

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**XV Conclusions and Recommendation (**Actions/decisions to be taken based on the interpretation of results).

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**XVI Practical Related Questions**

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

1. Write the status of the CY, AC and P flag after the addition of 1239CH and AC64H.
2. Write instructions to perform subtraction without borrow.
3. Write instructions to perform the following operations:
    a. Set the carry flag.
    b. Select Bank 2 of RAM memory.

**[Space for Answers]**

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## XVII References / Suggestions for further reading

1. https://www.pantechsolutions.net/...tutorials/subtraction-of-two-numbers-using-8051
2. https://electronicsforyou.in/8051-program-for-addition-of-two-16-bit-numbers/

## XVIII Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 5: ALP to perform addition of BCD data.

## I Practical Significance

8051 microcontrollers have single instruction arithmetic operations. Applications such as BCD and ASCII conversions and checksum byte testing require arithmetic operations. This practical will help the students to develop skills to write assembly program for arithmetic operations.

## II Industry/Employer expected outcome(s)

**Maintain microcontroller-based systems.**

### III Course Level Learning Outcome(s)

Develop program in 8051in assembly language for the given operation.

## IV Laboratory Learning Outcome(s)

Develop an ALP to perform addition of BCD data stored at external and store result in internal memory.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

Binary-Coded Decimal (BCD) is a method of representing decimal numbers where each digit is encoded as a separate 4-bit binary number. This allows for easier manipulation and display of decimal numbers in digital systems, such as microcontrollers and computers. The numbers from 0 to 9 are valid BCD whereas the numbers from A to F are invalid BCDs. Binary-Coded Decimal (BCD) addition in the 8051 microcontroller involves adding two BCD numbers and adjusting the result to ensure it remains in BCD format. If the result of addition results in an invalid BCD then suitable modification of addition of six is done to convert the number from invalid to valid BCD. For this in 8051 DAA instruction is used.

**DAA Instruction:**

The DAA (Decimal Adjust Accumulator) instruction is used in the 8051 microcontrollers to correct the result of a binary-coded decimal (BCD) addition operation. After adding two BCD numbers, the result might not be a valid BCD number. The DAA instruction adjusts the accumulator to ensure the result is a valid BCD number.

Conditions for Adjustment:

1. If the lower 4 bits (nibble) of the accumulator are greater than 9, or if the auxiliary carry (AC) flag is set, 6 is added to the lower nibble.
2. If the upper 4 bits (nibble) of the accumulator are greater than 9, or if the carry (C) flag is set, 6 is added to the upper nibble.

Ex: If the result of the addition is 0x3C (which is not a valid BCD), DA A will correct it to 0x42 (which is a valid BCD for the number 42).

## VII Resources Required

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1 | Desktop PC | Loaded with open-source IDE, simulation and program downloading software | 1 No. |

## VIII Precautions to be Followed

1. Check rules / syntax of assembly programming.

## IX Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL and select AT89C51.
5. Type the program in text editor and save as filename.asm extension.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window.
11. Note the values of the result of various operations in the observation table.

## E-Waste Management

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: To perform addition of BCD data stored at external and store the result in internal memory.

**Step 1-Algorithm**

1. Initialize Data pointer [DPTR] with memory location 2000H
2. Load the contents of memory location pointed by DPTR to Accumulator
3. Transfer the contents of A register to R0.
4. Increment DPTR
5. Load the contents of memory location pointed by DPTR to Accumulator
6. Perform the addition of contents of A register with R0 register.

7. Perform BCD adjustment on the result by using DA A instruction.
8. Move the contents of Accumulator (result) to internal memory location
9. Stop.

**Step 2-Flow Chart:**

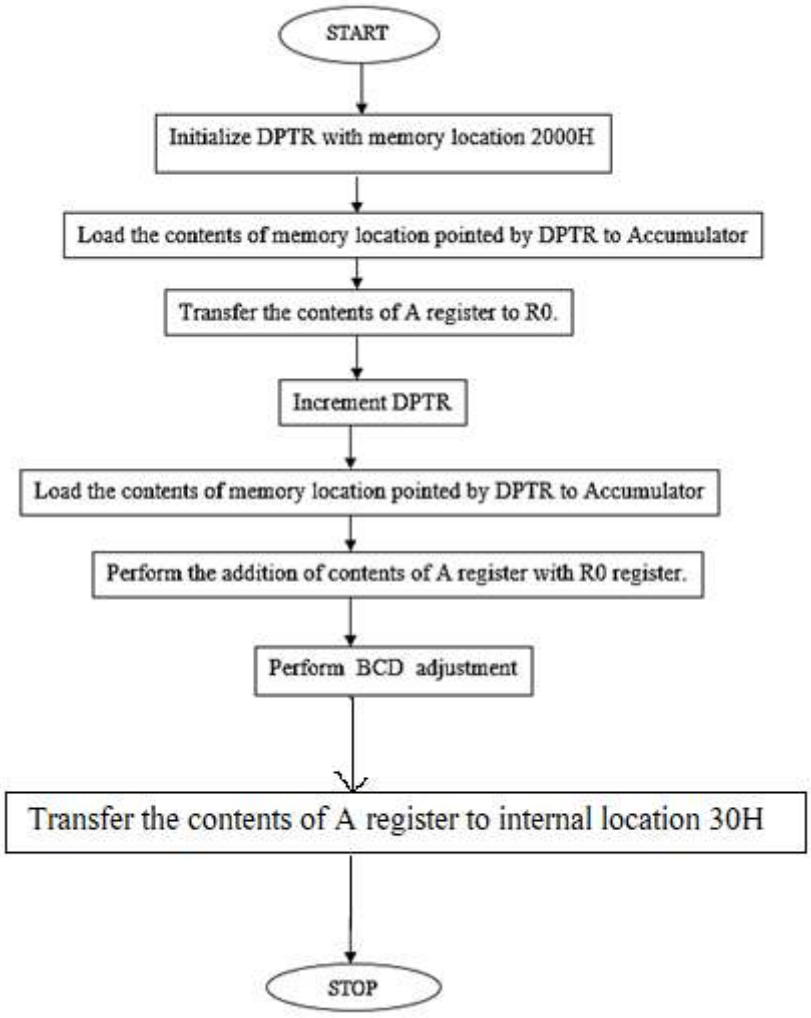


**Fig 5.1 Flowchart for BCD addition**

**Step 3- Assembly Language Sample Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 00H | |
| C:0x0000 | 902000 | | MOV DPTR, #2000H | Initialize Data pointer [DPTR] with memory location 2000H |
| C:0x0003 | E0 | | MOVX A, @DPTR | Load the contents of memory location pointed by DPTR to Accumulator |
| C:0x0004 | F8 | | MOV R0, A | Transfer the contents of A register to R0. |
| C:0x0005 | A3 | | INC DPTR | Increment DPTR |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x0006 | E0 | | MOVX A ,@DPTR | Load the contents of memory location pointed by DPTR to Accumulator |
| C:0x0007 | 28 | | ADD A, R0 | Perform the addition of contents of A register with R0 register |
| C:0x0008 | D4 | | DA A | Perform BCD adjustment on the result by using DA A instruction. |
| C:0x0009 | F530 | | MOV 30H, A | Transfer the result to internal memory location 30H. |
| | | | END | |

**Input and Output Window:**

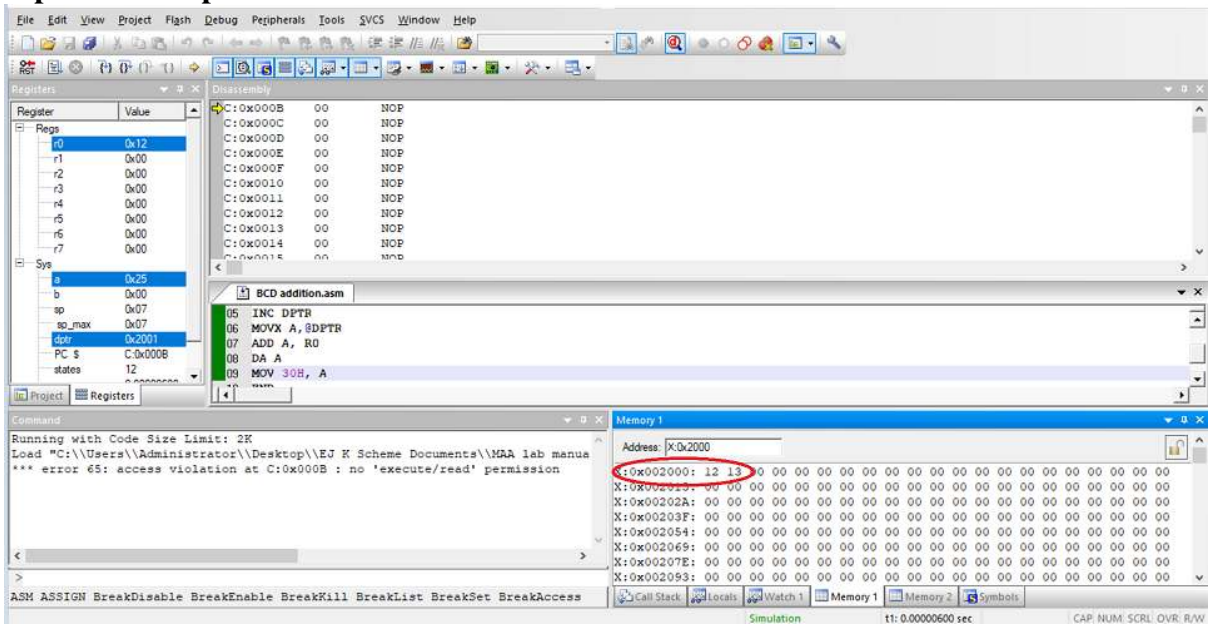


**Fig 5.2 Input Window**

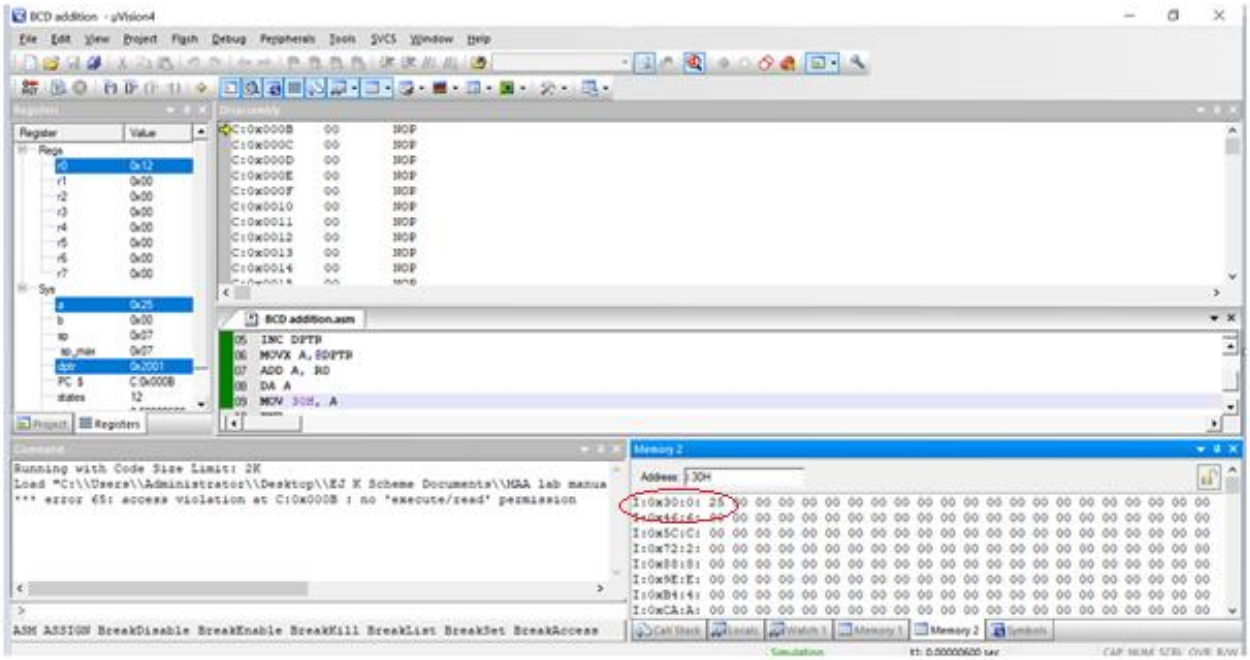


**Fig 5.2 Output Window**

**Problem statement 1 for student**: Write a program to perform BCD subtraction

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
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**X Resources Used:**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| | | | |

**XI Actual Procedure Followed** (use blank sheet provided if space not sufficient)

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**XIII Precautions Followed** (use blank sheet provided if space not sufficient)

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**XIV Observations for sample program** (use blank sheet provided if space not sufficient)

| Sr. No. | Memory Location used in the code | Contents after execution |
|---|---|---|
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| 2 | | |
| 3 | | |

**XV Results** (Output of the Program)

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**XVI Interpretation of Results (**Give meaning of the above obtained results)

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**XVII Conclusions and Recommendation (**Actions/decisions to be taken based on the Interpretation of results).

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## XVIII Practical Related Questions

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

1. Give the significance of Auxiliary carry and Carry flag while performing BCD operations.
2. Give the types of BCD number system.
3. List the applications of BCD number systems.

**[Space for Answers]**

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## XIX References / Suggestions for further reading

1. https://www.refreshnotes.com/2016/04/8051-program-addition-8bit-2digit-bcd.html
2. https://www.tutorialspoint.com/binary-coded-decimal-bcd-addition
3. https://www.vlsifacts.com/bcd-addition/

## XX Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 6: ALP to perform series addition.

## I Practical Significance

The series addition in the 8051 microcontroller is a fundamental aspect of its programming and functionality. Series addition is a basic arithmetic operation that is used extensively in various programming tasks within the microcontroller. It is often employed in loop mechanisms where iterative addition of values is required, essential for tasks like averaging or cumulative sums.

## II Industry/Employer expected outcome(s)

**Maintain microcontroller-based systems.**

### III Course Level Learning Outcome(s)

Develop program in 8051in assembly language for the given operation.

## IV Laboratory Learning Outcome(s)

Develop an ALP for sum of series stored in RAM locations 40 to 49H. Find the sum of the values at the end of program the lower byte stored in 30H and the high byte in 31H.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

The 8051 microcontrollers for performing series addition uses INC and DEC instructions for efficient byte increment and decrement operations, along with loop instructions and several iterations to get the final result.

**INC (Increment Instruction):** The INC instruction increases the value of a byte by one.
**Syntax:** INC operand
**Operands:** Can be an accumulator (A), a register (R0-R7), a direct address, a data pointer (DPTR), or an indirectly addressed memory location (@Ri).
**Example:** INC A: Increments the accumulator and result stored in accumulator.

**DEC (Decrement Instruction):** The DEC instruction decreases the value of a byte by one.
**Syntax:** DEC operand
**Operands:** Similar to INC, it can target the accumulator, a register, a direct address, or an indirectly addressed memory location.
**Example:** DEC A: Decrements the accumulator and result stored in accumulator.

**Branching Instructions**:

| Operation | Mnemonics | Description |
|---|---|---|
| Call | ACALL Address11 | Calls a subroutine in the maximum address range of 2K bytes |
| | LCALL Address16 | Calls a subroutine in the maximum address range of 64K bytes |
| Return | RET | Returns the control from subroutine |
| | RETI | Returns the control from an interrupt subroutine |
| Jump | AJMP Address11 | Jumps to an address in a 2KB range |
| | LJMP Address16 | Jumps to an address in a 64KB range |
| | SJMP Relative address | Jumps to an address in a 256-byte range (0 to 127 (0-7FH) range and -1 to -128 (FFH-80H). |
| | JMP @A+DPTR | [DPTR]<-[DPTR+A] |
| | JZ Relative address | Jumps to address when accumulator=0 |
| | JNZ Relative address | Jumps to address when accumulator =0 |
| | CJNE A, Direct address, Relative address | Jumps to relative address when accumulator=data stored at a direct address |
| | CJNE A, #Data, Relative address | Jumps to relative address when accumulator=data given by the programmer |
| | CJNE @Rn, #Data, Relative address | Jumps to relative address when data at memory location stored in register=data given by the programmer |
| | DJNZ Rn, Relative address | Decrements value in Rn and jump to relative address till Rn =0 |
| | DJNZ Direct address, Relative address | Decrements value at memory location stored in a register and jump to relative address till memory location stored in register =0 |

## VII Resources Required

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1 | Desktop PC | Loaded with open-source IDE, simulation and program downloading software | 1 No. |

## VIII Precautions to be Followed

1. Check rules / syntax of assembly programming.

## IX Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.

2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL and select AT89C51.
5. Type the program in text editor and save as filename.asm extension.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window.
11. Note the values of the result of various operations in the observation table.

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: Develop an ALP for sum of series stored in RAM locations 40 to 49H. Find the sum of the values at the end of program the lower byte stored in 30H and the high byte in 31H.

**Step 1-Algorithm**

1. Initialize Register R0 with the starting memory address.
2. Initialize Register R1 as counter to count the number of data values.
3. Initially clear register R2 and Accumulator.
4. Add the contents of Register A and contents of memory location pointed by R0.
5. Check whether carry flag is set or not. If carry flag is set then Increment register R2
6. Increment Register R0 to point to next number.
7. Decrement register R1 to check whether all additions are performed or not
8. If zero flag is not set then go to step 4 and repeat the process till all numbers are added
9. Move the contents of Accumulator (result) and Register R2 to memory location 30H and 31H.
10. Stop.

**Step 2-Flow Chart:**

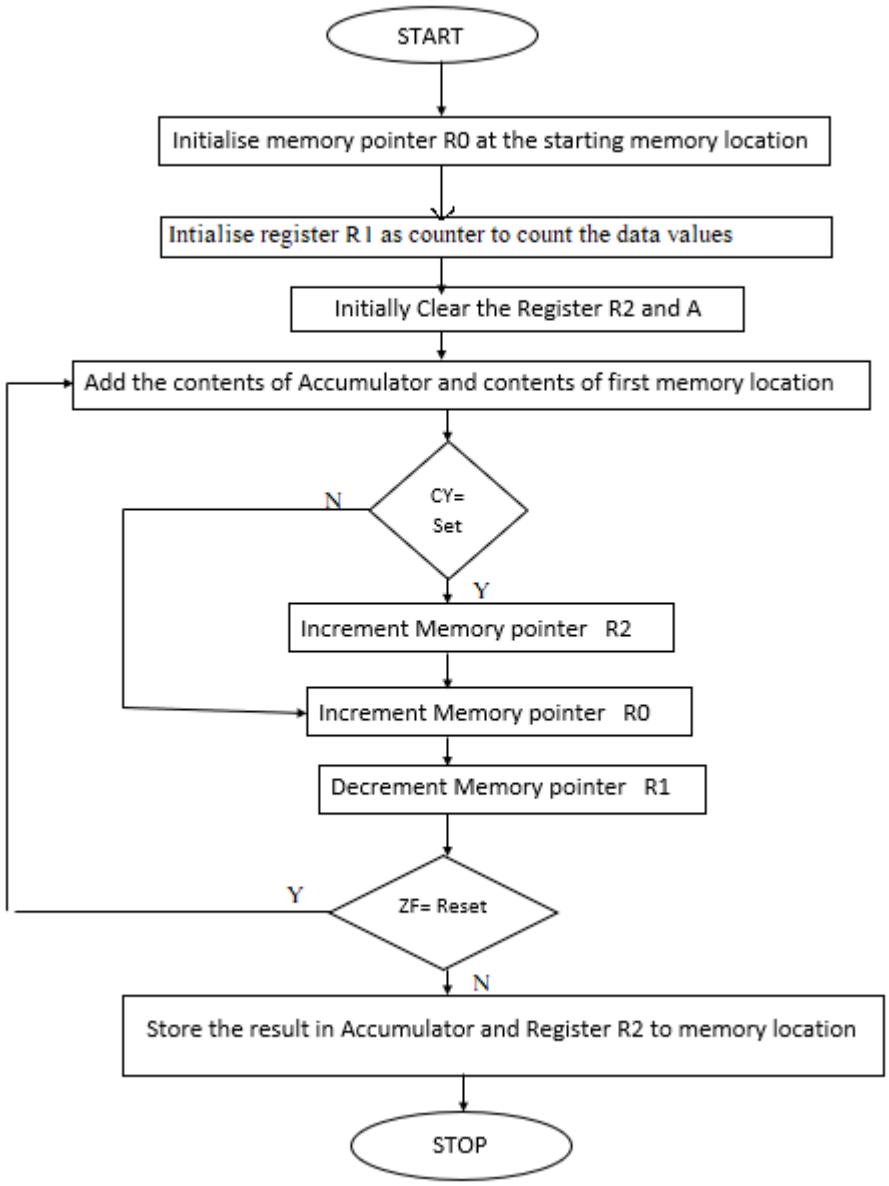


**Fig 6.1 Flowchart for Series addition**

**Step 3- Assembly Language Sample Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 00H | |
| C:0x0000 | 7840 | | MOV R0, #40H | Initialize Register R0 with memory location 40H |
| C:0x0002 | 790A | | MOV R1, #0AH | Initialize Register R1 with count value of 10 [0AH] |
| C:0x0004 | 7A00 | | MOV R2, #00H | Clear Register R2 |
| C:0x0006 | E4 | | CLR A | Clear Accumulator |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x0007 | 26 | RPT | ADD A, @R0 | Add the contents of register A and the contents of memory location pointed by R0. |
| C:0x0008 | 5001 | | JNC DOWN | Check the carry flag if it is not set then jump to label down |
| C:0x000A | 0A | | INC R2 | Increment the contents of Register R2 |
| C:0x000B | 08 | DOWN | INC R0 | Increment the contents of Register R0 |
| C:0x000C | D9F9 | | DJNZ R1, RPT | Decrement R1 and check if the contents are zero or non-zero. |
| C:0X000E | F530 | | MOV 30H, A | Move the contents of accumulator to memory location 30H |
| C:0X0010 | 8A31 | | MOV 31H, R2 | Move the contents of Register R2 to memory location 31H |
| | | | END | |

**Input and Output Window:**

**Input**

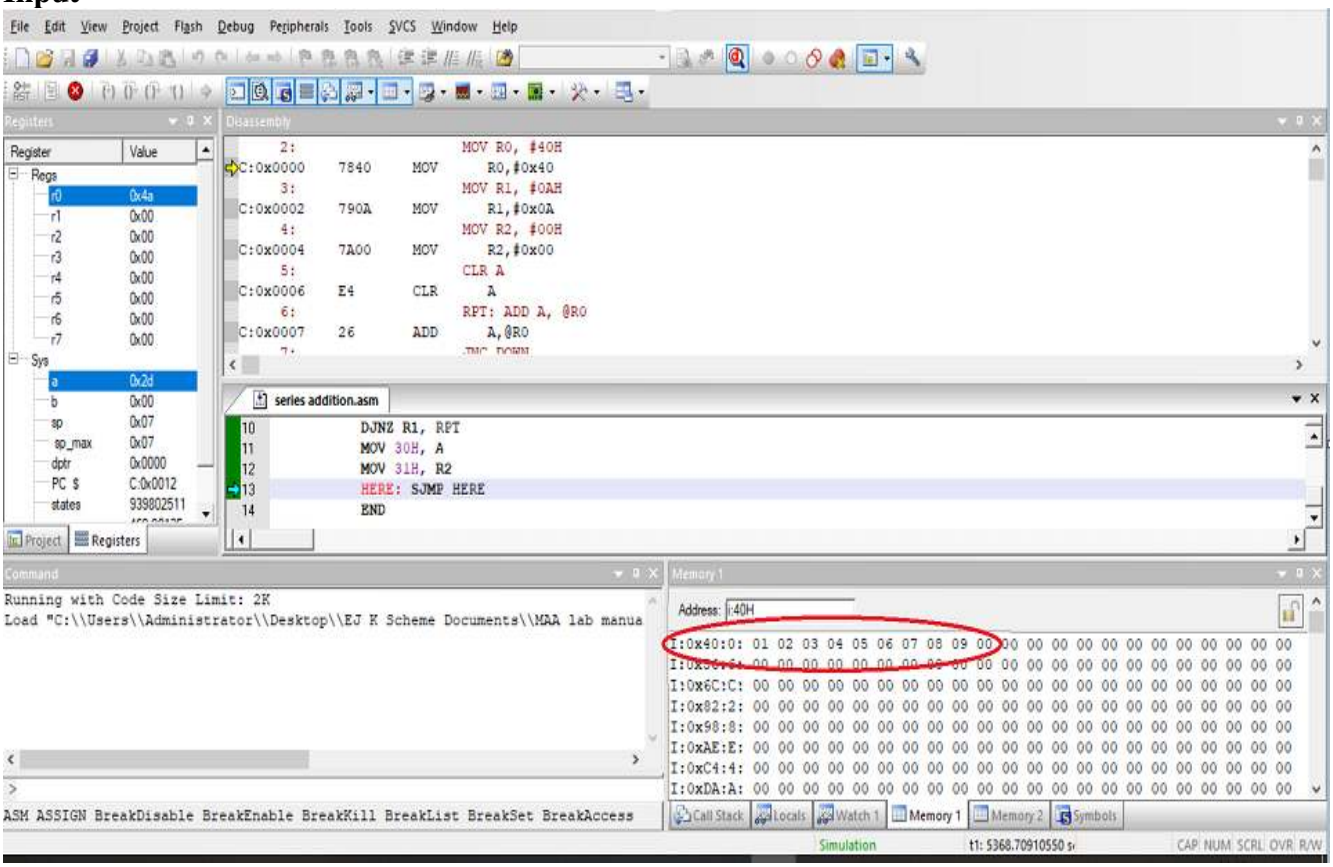


**Fig 6.2 Input Window**

## Output Window

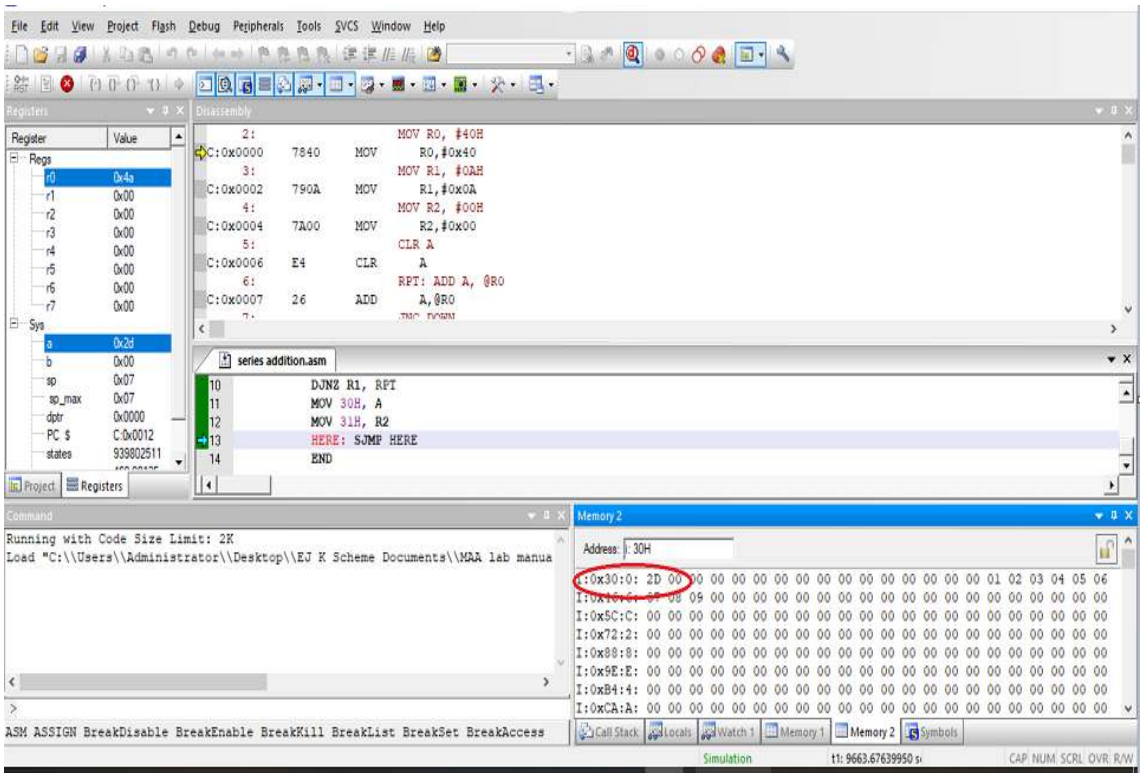


**Fig 6.3 Output Window**

**Problem statement 1 for student**: Write a program to perform Series addition of five numbers taken from external memory locations and store the result in registers R0 and R1 respectively.

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

| | |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | | |
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**X Resources Used:**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | | | |

**XI Actual Procedure Followed** (use blank sheet provided if space not sufficient)

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**XI Observations for sample program** (use blank sheet provided if space not sufficient)

| Sr. No. | Memory Location used in the code | Contents |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |
| 8 | | |
| 9 | | |
| 10 | | |

| Sr. No. | Memory Location used in the code | Contents of execution |
|---|---|---|
| 1 | | |
| 2 | | |

**XV Results** (Output of the Program)

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**XVI Interpretation of Results** (Give meaning of the above obtained results)

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**XVII Conclusions and Recommendation (**Actions/decisions to be taken based on the interpretation of results).

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**XVIII Practical Related Questions**

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

1. MOV A, # 55H
   RLC A
   Give the Contents of accumulator and status of carry flag after execution of the above two instructions.
2. Give the instructions used to set and clear the carry flag.
3. Give the sequence of instructions used to perform subtraction without borrow.

**[Space for Answers]**

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## XIX References / Suggestions for further reading

1. https://electronicsforyou.in/8051-program-to-add-an-array-of-numbers/
2. https://www.tutorialspoint.com/program-branch-group-in-8051
3. https://www.refreshnotes.com/2016/04/8051-program-sum-of-set-of-numbers-in.html

## XX Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40% (10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 % (25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 7: Array data transfer from source locations to destination locations

## I Practical Significance

Understanding 8051 microcontroller memory organization helps in making optimal use of internal RAM and ROM. For applications which require additional memory, the external memory can be accessed. This practical will help the students to develop skills to transfer data from source to destination location.

## VI Industry/Employer Expected Outcome(s)

Maintain microcontroller based systems.

## III Course Level Learning Outcome(s)

Develop program in 8051 in assembly language for the given operation.

## IV Laboratory Learning Outcome(s)

Develop an ALP to transfer data from source to destination locations of internal/ external data memory.

## V Relevant Affective Domain related outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

Microcontroller 8051 has two types of memory, **Program Memory** and **Data Memory**. Program Memory (ROM) is used to permanently save the program being executed, while Data Memory (RAM) is used for temporarily storing data and intermediate results created and used during the operation of the microcontroller.

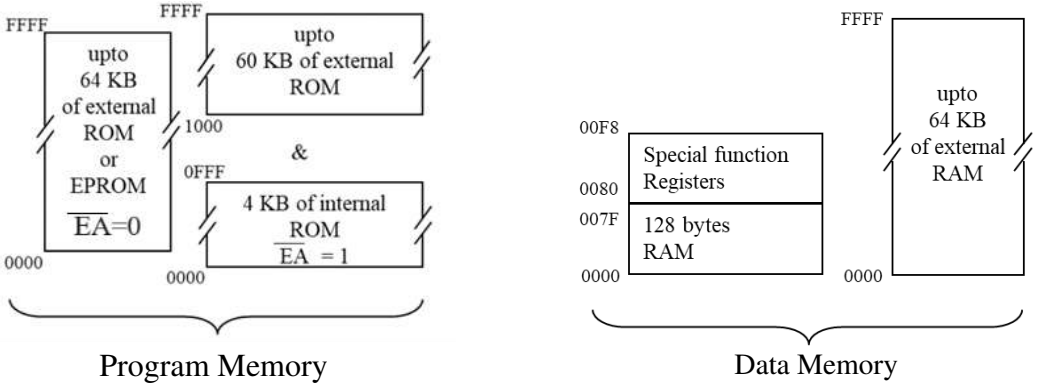


**Fig. 7.1 8051 memory organization**

The 8051 microcontroller uses data transfer instructions to move data between internal RAM locations, as well as between internal and external RAM.

**Internal RAM data transfer instructions:**

**Table 7.1 : Data Transfer Instruction**

| Mnemonics | Description |
|---|---|
| MOV A, direct | Move direct byte to Accumulator |
| MOV A, @Ri | Move indirect RAM to Accumulator |
| MOV Rn, direct | Move direct byte to Register |
| MOV direct, A | Move Accumulator to direct byte |
| MOV direct, Rn | Move register to direct byte |
| MOV direct, direct | Move direct byte to direct byte |
| PUSH direct | Push direct byte onto stack |
| POP direct | Pop direct byte from stack |
| XCH A, direct | Exchange direct byte with Accumulator |
| XCH A, @Ri | Exchange indirect RAM with Accumulator |
| XCHD A, @Ri | Exchange low-order nibble indirect RAM with Accumulator |

**Instructions to Access External Data Memory:**

**Table 7.2: External Data Access Instructions**

| Mnemonic | Description |
|---|---|
| MOVX A, @Rp | Copy the contents of the external memory address in Rp to A. |
| MOVX A. @DPTR | Copy the contents of the external memory address in DPTR to A. |
| MOVX @Rp. A | Copy data from A to the external memory address in Rp |
| MOVX @DPTR, A | Copy data from A to the external memory address in DPTR. |

## XVII Required Resources/apparatus/equipment with specifications

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Desktop PC | Loaded with open-source IDE, simulation and program downloading software. | 1 No. |

## XVIII Precautions to be followed

1) Check rules / syntax of assembly language programming.

## XIX Procedure

**Develop Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL or INTEL and select 80c51AH or AT89C51.
5. Type the program in text editor and save as .asm or .a51.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window. It will display all internal registers of 8051 and their contents.
11. Observe the contents of internal and external data memory.

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1:** Write a program to transfer a block of 5 data bytes from internal source data memory locations 40H onwards to destination memory locations 50H onwards.

**Step 1: Algorithm**

1. Set program starting address.
2. Initialize source memory pointer R0 to 40H.
3. Initialize destination memory pointer R1 to 50H.
4. Initialize iteration count R2 to 05H.
5. Move content of first location into accumulator.

6. Move the content of accumulator to first destination location.
7. Increment source memory pointer.
8. Increment destination memory pointer.
9. Decrement iteration count, and jump to step 5, if not zero.
10. Stop

**Step 2-Flowchart**

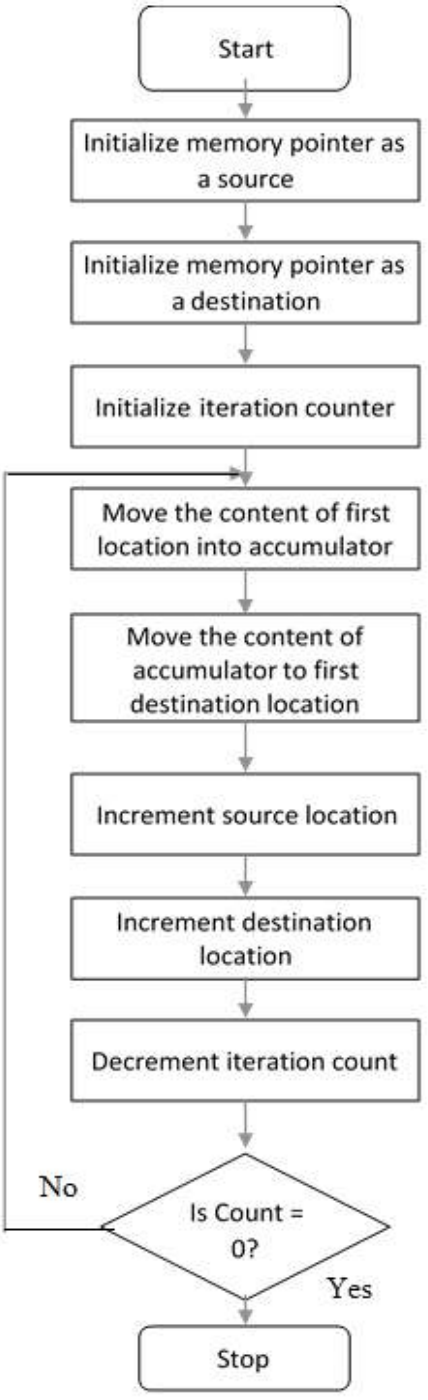


**Fig. 7.2 Flowchart to transfer a block of data**

### Step 3: Assembly Language Program

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x0000 | | | ORG 0000H | |
| C:0x0000 | 7840 | | MOV R0, #40H | ;Initialize source memory pointer R0 to 40H |
| C:0x0002 | 7950 | | MOV R1, #50H | ;Initialize destination memory pointer R1 to 50H |
| C:0x0004 | 7A05 | | MOV R2, #05H | ;Initialize iteration count to 05H |
| C:0x0006 | E6 | UP: | MOV A, @R0 | ;Move the contents of source memory pointed by R0 to Accumulator |
| C:0x0007 | F7 | | MOV @R1, A | ;Move the contents of Accumulator to destination memory pointed by R1 |
| C:0x0008 | 08 | | INC R0 | ;Increment the contents of R0 |
| C:0x0009 | 09 | | INC R1 | ;Increment the contents of R1 |
| C:0x000A | DAFA | | DJNZ R2, UP | ; Decrement counter by one, Is it zero? No ,jump to UP |
| | | | END | |

### Output Window

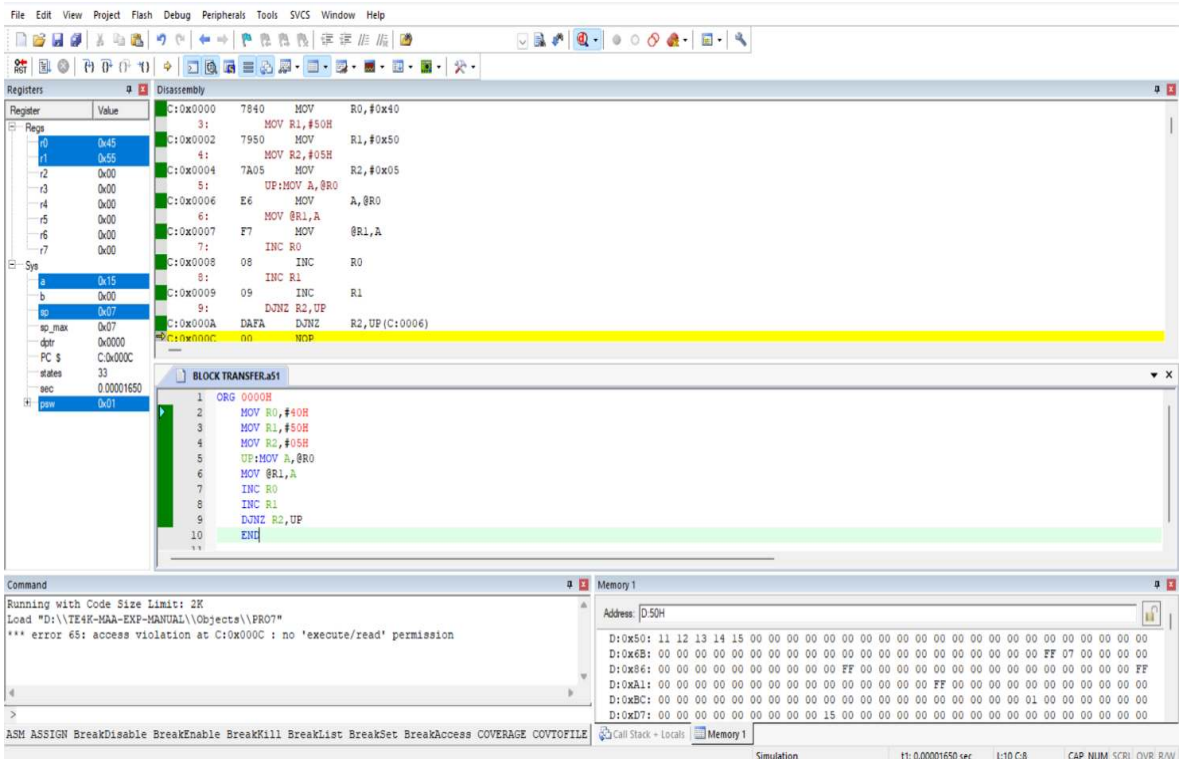


**Fig 7.3 Output Window**

**Problem statement for student:** Write a program to transfer a block of 05 bytes from internal data memory location 20H onwards to external data memory location 2000H onwards

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | | |
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**XX Resources used**

| Sr. No. | Name of Resource | Specifications | Quantity |
|---|---|---|---|
| | | | |
| | | | |

**XXI Actual Procedure Followed** (use blank sheet provided if space not sufficient)

1. ……..
2. ……
3. …….
4. ……
5. ……
6. ……
7. ……
8. ……

**XII Observations for problem statement 1** (use blank sheet provided if space not sufficient)

| Before execution | | After execution | |
|---|---|---|---|
| Memory location | Data | Memory location | Data |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**XIII Results (Output of the Program)**

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**XIV Interpretation of Results (Give meaning of the above obtained results)**

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**XV Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

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**XVI Practical related questions**

***Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.***

1. State any two instructions used to access external memory in 8051.
2. State registers used as memory pointers in 8051.
3. Explain the operation of following instructions:
   a) XCHD A, @R1 b) PUSH 30H

**[Space for Answers]**

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## XVII References/Suggestions for further reading

1. https://www.silabs.com/documents/public/presentations/8051_Instruction_Set.pdf
2. https://www.daenotes.com/electronics/digital-electronics/8051-microcontroller-instruction-types
3. https://www.electronicshub.org/8051-microcontroller-memory-organization/

## XVIII Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 8: Block exchange of data from source locations to destination locations.

## I Practical Significance

Data transfer is a process of moving or copying information from one location to other location within internal or external data memory. To save the results of certain operations, to create lookup tables etc. these data transfer programs are required. Block data transfer is more efficient than byte-by-byte operations, especially when dealing with large data sets. It minimizes overhead by reducing the number of instruction cycles required for data movement.

## II Industry/Employer expected outcome(s)

**Maintain microcontroller-based systems.**

### III Course Level Learning Outcome(s)

Develop program in 8051 in assembly language for the given operation.

## IV Laboratory Learning Outcome(s)

Develop an ALP to exchange data from source to destination locations of internal/external memory locations.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

The 8051 microcontroller memory is divided into Program Memory and Data Memory. Program Memory (ROM) is used for permanent saving program being executed, while Data Memory (RAM) is used for temporarily storing and keeping intermediate results and variables.

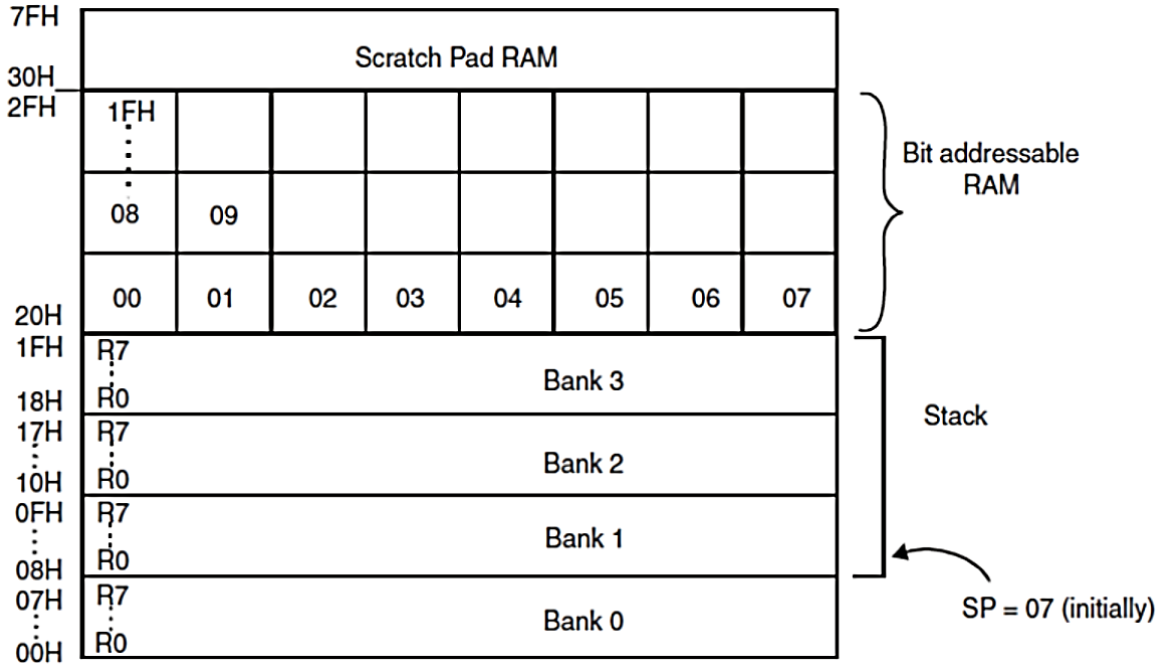


**Fig 8.1 RAM Organization in 8051**

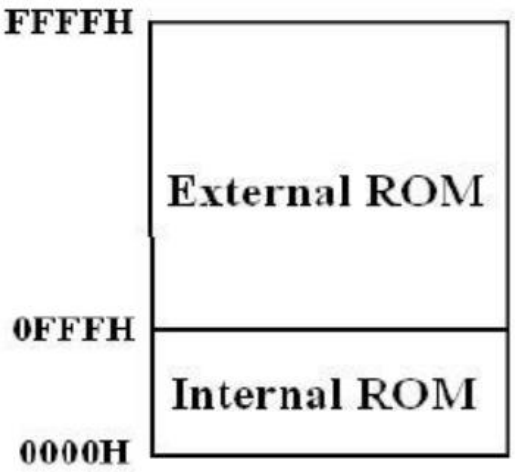


**Fig 8.2 ROM Organization in 8051**

The 8051 microcontroller includes 128 bytes of internal RAM and up to 4 KB of internal ROM:

1. **RAM (128 bytes)**: Divided into working registers, bit-addressable area, and general storage.
2. **ROM (4 KB)**: Stores the microcontroller's firmware, typically used for storing the program that the 8051 executes. Locations from 0000H to 0FFFH are internal locations and that exceeds 0FFFH are external locations.

These memory components are integral for the operation and flexibility of the 8051 in various applications.

## VII Resources Required

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1 | Desktop PC | Loaded with open-source IDE, simulation and program downloading software | 1 No. |

## VIII Precautions to be Followed

1. Check rules / syntax of assembly programming.

## IX Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL and select AT89C51.
5. Type the program in text editor and save as filename.asm extension.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window.
11. Note the values of the result of various operations in the observation table.

## E-Waste Management

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: **Write and execute a program to exchange five data bytes of internal memory location from 50H to 60H onwards.**

### Step 1-Algorithm

1. Start
2. Initialize memory pointer as a source.
3. Initialize memory pointer as a destination.
4. Initialize counter.
5. Move the content of first location into accumulator.
6. Move the content of accumulator to first destination location.
7. Increment source location.
8. Increment destination location.
9. Move the contents of Accumulator to source locations

10. If zero flag is not set then go to step 4 and repeat the process till all numbers are added
11. Decrement iteration count and if not zero jump to step 5.
12. Stop.

**Step 2-Flow Chart:**

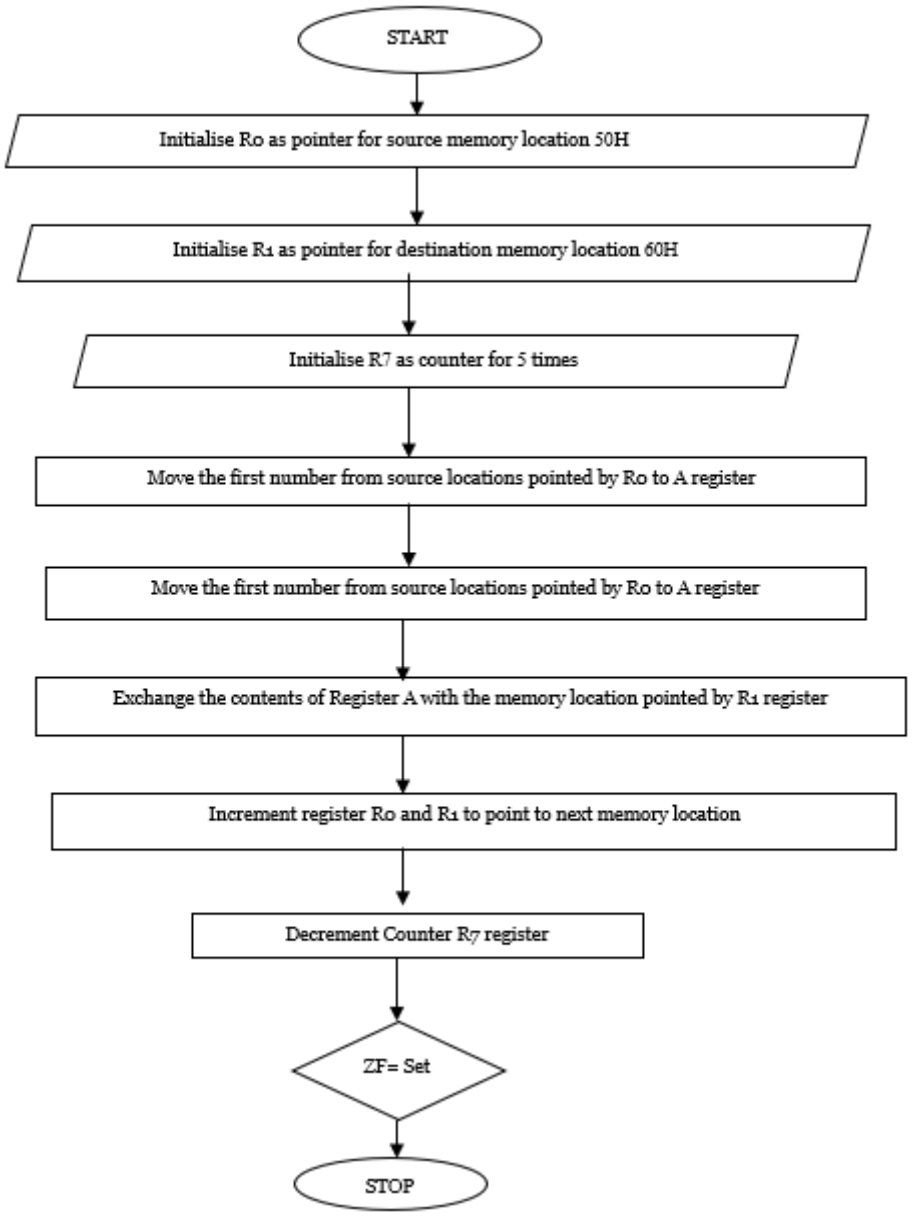


**Fig 8.3 Flowchart for Block Exchange**

**Step 3- Assembly Language Sample Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 00H | |
| C:0x0000 | 7850 | | MOV R0,#50H | Initialize memory pointer R0 as a source |
| C:0x0002 | 7960 | | MOV R1, #60H | Initialize memory pointer R1 as a destination |
| C:0x0004 | 7F05 | | MOV R7, #05H | Initialize counter. |
| C:0x0006 | E6 | UP | MOV A, @R0 | Move the content of first location in to accumulator. |
| C:0x0007 | C7 | | XCH A, @R1 | Exchange with destination memory |
| C:0x0008 | F6 | | MOV @R0,A | Move the contents of Accumulator to source locations |
| C:0x0009 | 08 | | INC R0 | Increment source location |
| C:0x0009 | 09 | | INC R1 | Increment destination location |
| C:0x000A | DFF9 | | DJNZ R7, UP | Decrement iteration count and if not zero jump to step 5. |
| | | | END | |

**Input and Output Window:**

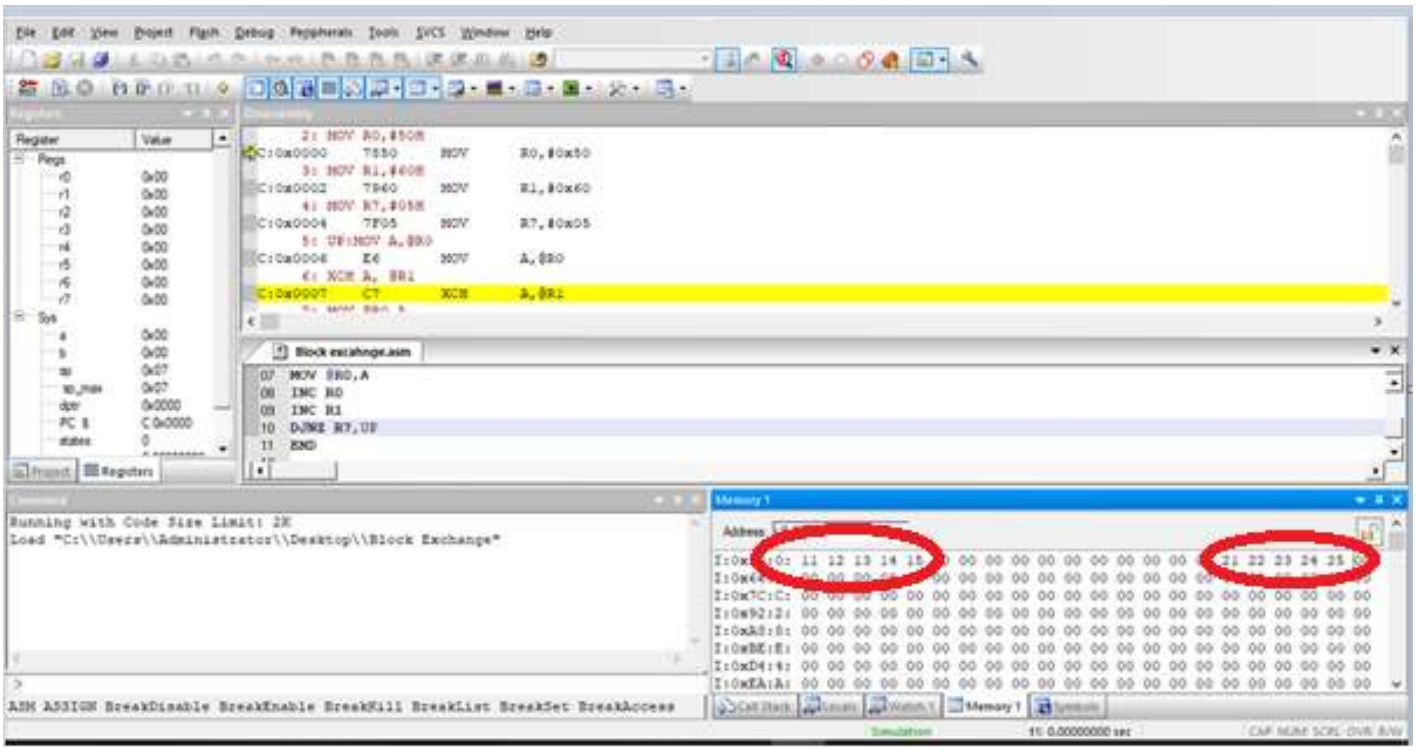


**Fig 8.4 Before Execution Window**

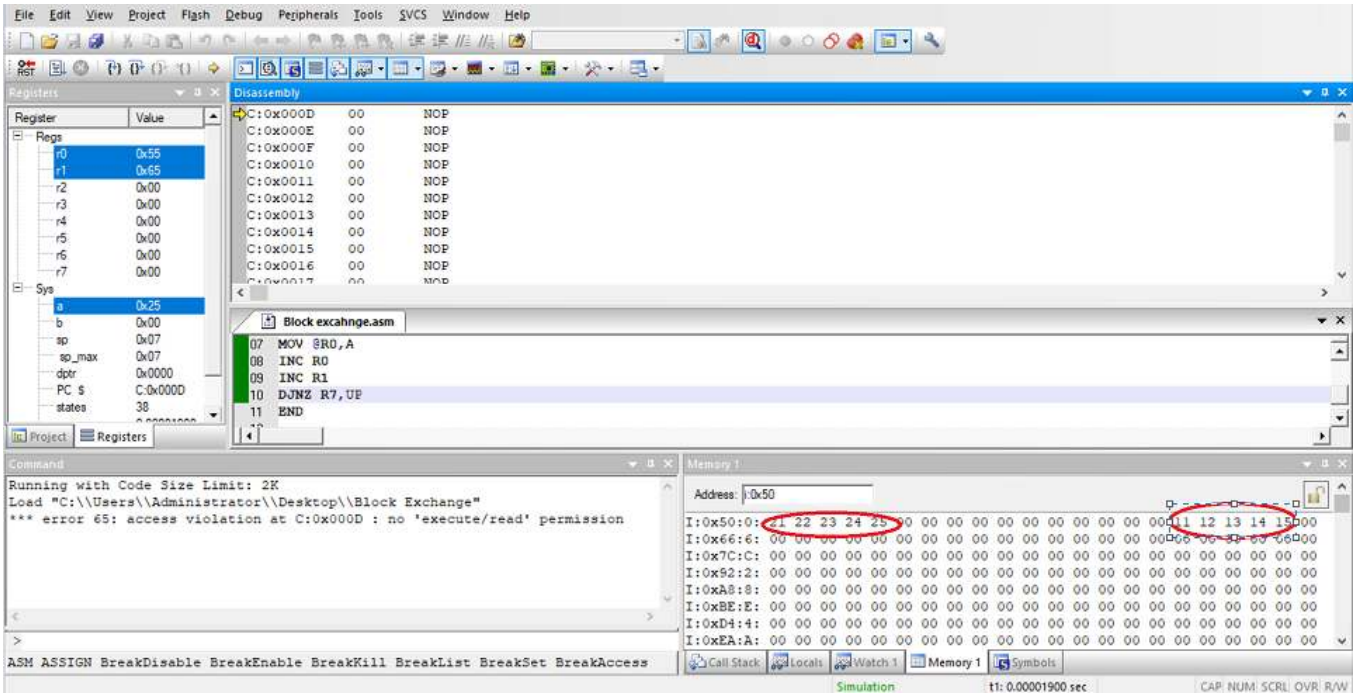


**Fig 8.5 After Execution Window**

**Problem statement 1 for student**: Write a program to perform Block Exchange from source to destination using external memory locations.

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | | |
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**X Resources Used:**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | | | |

**XI Actual Procedure Followed** (use blank sheet provided if space not sufficient)

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**XI Observations for sample program** (use blank sheet provided if space not sufficient)

| Before execution | | | | After execution | | | |
|---|---|---|---|---|---|---|---|
| **Memory Address** | **Contents** | **Memory Address** | **Contents** | **Memory Address** | **Contents** | **Memory Address** | **Contents** |
| | | | | | | | |
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**XV Results** (Output of the Program)

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**XVI Interpretation of Results (**Give meaning of the above obtained results)

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**XVII Conclusions and Recommendation (**Actions/decisions to be taken based on the interpretation of results).

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## XVIII Practical Related Questions

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

1. Write program to perform block transfer from source to destination memory locations.
2. Give the significance of DPTR in using external memory locations.
3. Give the importance of $\overline{EA}$ pin in 8051

**[Space for Answers]**

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## XIX References / Suggestions for further reading

1. https://www.refreshnotes.com/2016/04/8051-program-exchange-block-of-data.html
2. https://www.tutorialspoint.com/program-branch-group-in-8051
3. https://www.codesexplorer.com/2016/12/8051-alp-to-move-data-from-internal-to-external.html

## XX Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| | Performance indicators | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40% (10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 % (25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 9: Finding the smallest number from the given data bytes

## I Practical Significance

Microcontrollers use compare operation to test or compare register values. The results of these operations can update flag bits, which can then be used to change program flow through conditional execution. This practical will help the students to develop skills to use the compare and loop instructions to find smallest number from a block of data bytes.

## II Industry/Employer Expected Outcome(s)

Maintain microcontroller based systems.

## III Course Level Learning Outcome(s)

Develop program in 8051 in assembly language for the given operation.

## IV Laboratory Learning Outcome(s)

Develop an ALP for identifying smallest number from the given data bytes stored in internal/ external data memory

## V Relevant Affective Domain related outcome(s)

Follow ethical practices.

## V I Relevant Theoretical Background

In 8051 microcontroller, instructions CJNE and DJNZ can be used in combination for finding smallest number from a block of data bytes.

**CJNE : Compare and Jump If Not Equal -**

CJNE compares the value of two operands and branches to the indicated relative address if operands are not equal. If the two operands are equal program flow continues with the instruction following the CJNE instruction. CY flag is affected. CY flag is set if the first operand is smaller than second operand else it is reset.

| Mnemonic | Description |
|---|---|
| CJNE A,direct,rel | Compares direct byte to the accumulator and jumps if not equal. |
| CJNE A,#data,rel | Compares immediate data to the accumulator and jumps if not equal |
| CJNE Rn,#data,rel | Compares immediate data to the register and jumps if not equal. |
| CJNE @Ri,#data,rel | Compares immediate data to indirect register and jumps if not equal. |

**DJNZ Rn, relative**

This instruction decrements the contents of register by 1 and jump to the relative address if not zero.

## VII Required Resources/apparatus/equipment with specifications

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Desktop PC | Loaded with open-source IDE, simulation and program downloading software. | 1 No. |

## VIII Precautions to be followed

1) Check rules / syntax of assembly language programming.

## IX Procedure

**Develop Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL or INTEL and select 80c51AH or AT89C51.
5. Type the program in text editor and save as .asm or .a51.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window. It will display all internal registers of 8051 and their contents.
11. Note down the readings in observation table

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1:** Write a program to find smallest number from the given array of 05 data bytes stored in internal RAM locations 30H onwards and store the smallest number in location 40H.

**Step 1: Algorithm**

1. Initialize the comparison count to 04H which is number of data bytes minus one.
2. Initialize source memory pointer R0 to 30H.
3. Move the contents of source location pointed by R0 to Accumulator
4. Increment source memory pointer
5. Move the contents of source location to register B
6. Compare the two numbers.
7. If number in A is less than number in B, then go to step 9.

8. Move smallest number from register B to register A
9. Decrement comparison count by 1.
10. If count is not zero go to step 4.
11. Store the smallest number from register A location 40H

**Step 2- Flow Chart**

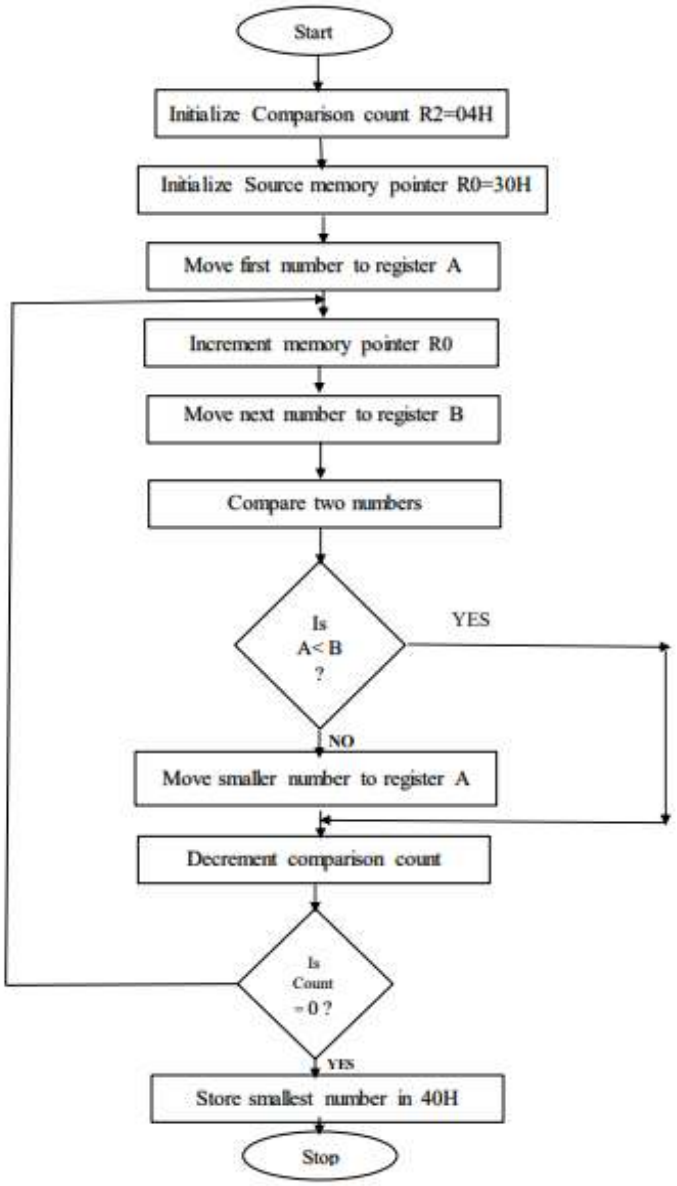


**Fig 5.1 Flowchart to find smallest number**

**Step 3: Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | |
| C:0x0000 | 7A04 | | MOV R2,#04H | ;Initialize Comparison count |
| C:0x0002 | 7830 | | MOV R0,#30H | ;Initialize Source memory pointer R0=30H |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x0004 | E6 | | MOV A,@R0 | ;Move first number to register A |
| C:0x0005 | 08 | UP: | INC R0 | ;Increment memory pointer |
| C:0x0006 | 86F0 | | MOV B,@R0 | ;Move next number to register B |
| C:0x0008 | B5F0000 | | CJNE A,B, DOWN | ;Compare two numbers |
| C:0x000B | 4002 | DOWN: | JC SMALL | ;If number in register A is Smaller than number in register B, jump DOWN |
| C:0x000D | E5F0 | | MOV A,B | ;Move smaller number in register B to A |
| C:0x000F | DAF4 | SMALL | DJNZ R2,UP | ;Decrement comparison count, if count ≠ 0, jump UP |
| C:0x0011 | F540 | | MOV 40H, A | ;Move smallest number to location 40h |
| | | | END | |

**Output Window**

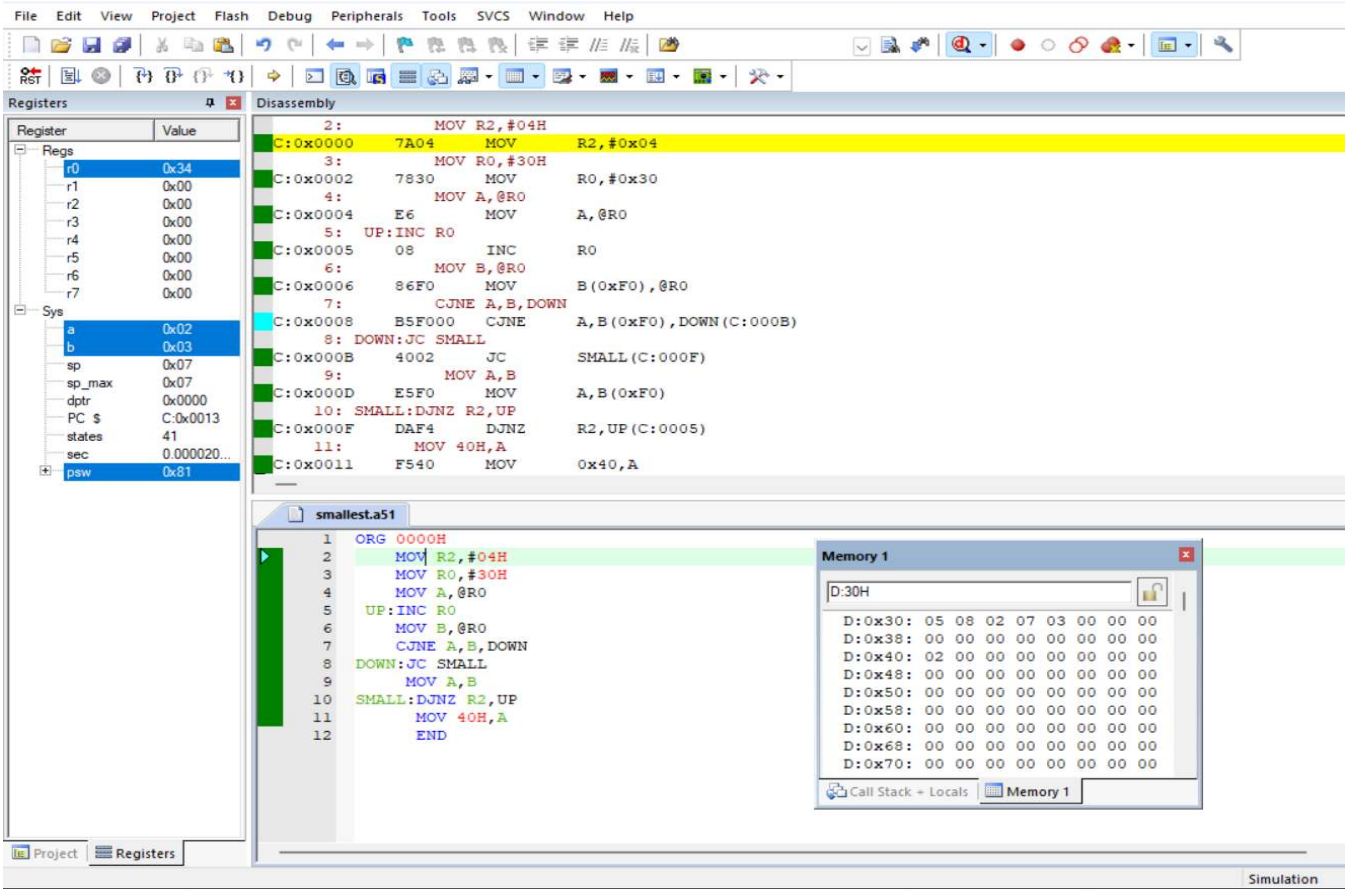


**Fig 5.2 Output Window**

**Problem statement for student:** Write a program to find smallest number from the given array of 05 data bytes stored in External RAM locations 3000H onwards and store the smallest number in location 4000H.

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
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**X Resources used**

| Sr. No. | Name of Resource | Specifications | Quantity |
|---|---|---|---|
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**XI Actual Procedure Followed** (use blank sheet provided if space not sufficient)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……

**XII Observations for problem statement** (use blank sheet provided if space not sufficient)

| Before execution | | After execution | |
|---|---|---|---|
| Memory location | Data | Memory location | Data |
| 3000H | | 4000H | |
| 3001H | | | |
| 3002H | | | |
| 3003H | | | |
| 3004H | | | |

**XIII Results (Output of the Program)**

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**XIV Interpretation of Results (Give meaning of the above obtained results)**

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**XV Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

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**XVI Practical related questions**

***Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.***

1. State the significance of counter in finding smallest number from series of numbers.
2. Explain the internal operation performed by CPU while executing CJNE instruction. Also state the effect on CY flag
3. Give the status of CY Flag when following instructions are executed:

```
    MOV A, #05H
GO: CJNE A, #05H, GO
    END
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**[Space for Answers]**

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## XVII References/Suggestions for further reading


1. https://josephscollege.ac.in/lms/Uploads/pdf/material/Instruction_set_of_Microcontroller_8051.pdf
2. https://www.refreshnotes.com/2016/04/8051-program-smallest-element-in-array.html
3. https://www.daenotes.com/electronics/digital-electronics/8051-microcontroller-instruction-types
4. https://www.keil.com/support/man/docs/a51/a51_cjne.htm


## XVIII Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 10: Finding the Largest number from the given data bytes

## I Practical Significance

Microcontrollers use compare operation to test or compare register values. The results of these operations can update flag bits, which can then be used to change program flow through conditional execution. This practical will help the students to develop skills to use the compare and loop instructions to find largest number from a block of data bytes.

## II Industry/Employer Expected Outcome(s)

Maintain microcontroller-based systems.

## III Course Level Learning Outcome(s)

Develop program in 8051 in assembly language for the given operation.

## IV Laboratory Learning Outcome(s)

Develop an ALP for identifying largest number from the given data bytes stored in internal/ external data memory

## V Relevant Affective Domain related outcome(s)

Follow ethical practices.

## V I Relevant Theoretical Background

In 8051 microcontroller, instructions CJNE and DJNZ can be used in combination for finding smallest number from a block of data bytes.

**CJNE : Compare and Jump If Not Equal -**

CJNE compares the value of two operands and branches to the indicated relative address if operands are not equal. If the two operands are equal program flow continues with the instruction following the CJNE instruction. CY flag is affected. CY flag is reset if the first operand is Larger than second operand. Carry flag status can be checked using instructions JC and JNC.

**JC: Jump if Carry Set**

Syntax: JC relative aaddress

This instruction will branch to the address indicated by relative address if the Carry flag is set. If the Carry flag is not set program execution continues with the instruction following the JC instruction.

**JNC: Jump if Carry is not Set**

Syntax: JNC relative address

This instruction will branch to the address indicated by relative address if the Carry flag is not set.

If the Carry flag is set program execution continues with the instruction following the JC instruction.

## VII Required Resources/apparatus/equipment with specifications

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Desktop PC | Loaded with open-source IDE, simulation and program downloading software. | 1 No. |

## VIII Precautions to be followed

1) Check rules / syntax of assembly language programming.

## IX Procedure

**Develop Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL or INTEL and select 80c51AH or AT89C51.
5. Type the program in text editor and save as .asm or .a51.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window. It will display all internal registers of 8051 and their contents.
11. Note down the readings in observation table

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1:** Write a program to find Largest number from the given array of 05 data bytes stored in external RAM locations 3000H onwards and store the Largest number in location 3010H.

**Step 1: Algorithm**

1. Initialize the comparison count to 04H which is number of data bytes minus one.
2. Initialize external source memory pointer DPTR to 3000H.
3. Move the contents of external source location pointed by DPTR to Accumulator
4. Move data in register A to register B
5. Increment source memory pointer
6. Move the contents of source location to register A
7. Compare the two numbers.
8. If number in A is larger than number in B, then go to step 10.

9. Move largest number from register B to register A
10. Decrement comparison count by 1.
11. If count is not zero go to step 4.
12. Store the smallest number from register A location 3010H

**Step 2: Flowchart Step 1: Algorithm**

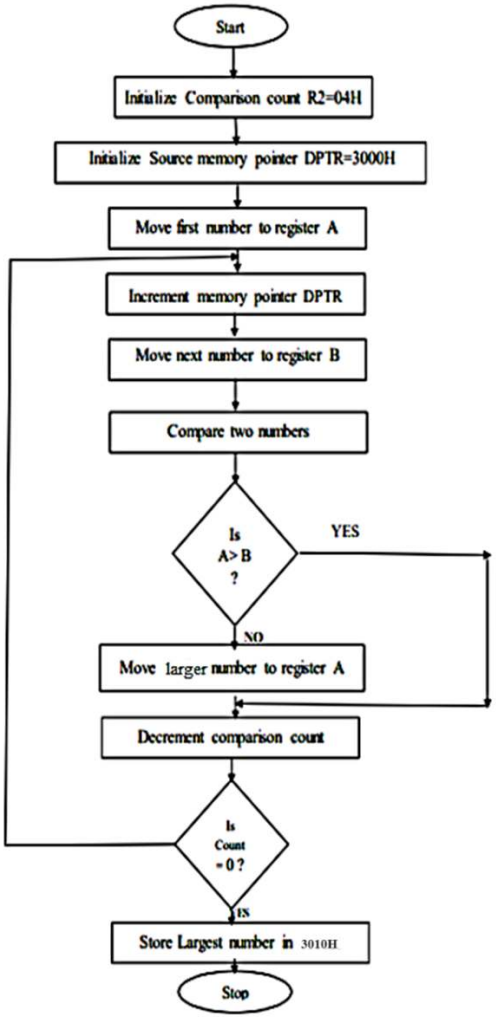


**Fig 10.1 Flowchart to find Largest number**

**Step 3: Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | |
| C:0x0000 | 7A04 | | MOV R2,#04H | ;Initialize Comparison count |
| C:0x0002 | 903000 | | MOV DPTR,#3000H | ;Initialize Source memory pointer R0=30H |
| C:0x0005 | E0 | | MOVX A,@DPTR | ;Move first number to register B |
| C:0x0006 | F5F0 | UP: | MOV B,A | |
| C:0x0008 | A3 | | INC DPTR | ;Increment memory pointer |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x0009 | E0 | | MOVX A,@DPTR | ;Move next number to register A |
| C:0x000A | B5F000 | | CJNE A,B, DOWN | ;Compare two numbers |
| C:0x000D | 5002 | DOWN: | JNC LARGE | ;If number in register A is Smaller than number in register B, jump DOWN |
| C:0x000F | E5F0 | | MOV A,B | ;Move larger number in register B to A |
| C:0x0011 | DAF3 | LARGE: | DJNZ R2,UP | ;Decrement comparison count, if count ≠ 0, jump UP |
| C:0x0013 | 903010 | | MOV DPTR,#3010H | |
| C:0x0016 | F0 | | MOVX @DPTR, A | ;Move smallest number to location 3010H |
| C:0x00017 | 80FE | HERE: | SJMP HERE | ;Stop |
| | | | END | |

**Output Window**

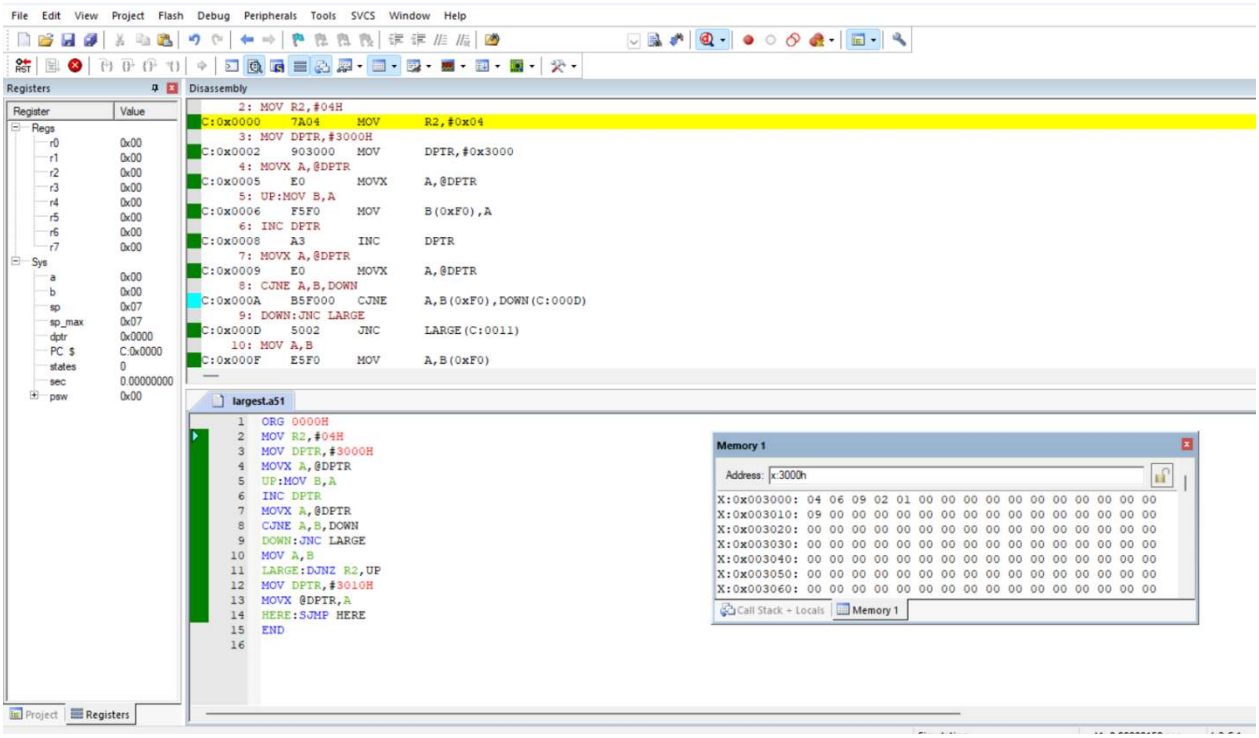


**Fig 10.2 Output Window**

**Problem statement for student:** Write a program to find Largest number from the given array of 10 data bytes stored in internal RAM location 50H onwards and store the Largest number in location 60H.

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
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**X Resources used**

| Sr. No. | Name of Resource | Specifications | Quantity |
|---|---|---|---|
| | | | |
| | | | |

**XI Actual Procedure Followed** (use blank sheet provided if space not sufficient)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……

**XII Observations for problem statement** (use blank sheet provided if space not sufficient)

| Before execution | | After execution | |
|---|---|---|---|
| Memory location | Data | Memory location | Data |
| 50H | | 60H | |
| 51H | | | |
| 52H | | | |
| 53H | | | |
| 54H | | | |
| 55H | | | |
| 56H | | | |
| 57H | | | |
| 58H | | | |
| 59H | | | |

**XIII Results (Output of the Program)**

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**XIV Interpretation of Results (Give meaning of the above obtained results)**

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**XV Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

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**XVI Practical related questions**

***Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.***

1. State the function of DPTR register.
2. Explain operation of instruction MOVX @DPTR, A

**[Space for Answers]**

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## XVII References/Suggestions for further reading


1. https://electronicsforyou.in/8051-program-to-find-the-largest-number-in-an-array/
2. https://josephscollege.ac.in/lms/Uploads/pdf/material/Instruction_set_of_Microcontroller_8051.pdf
3. https://www.refreshnotes.com/2016/04/8051-program-smallest-element-in-array.html
4. https://www.daenotes.com/electronics/digital-electronics/8051-microcontroller-instruction-types


## XVIII Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

## Practical No. 11: Arranging numbers in Ascending order

## I Practical Significance

Sorting is any process of arranging information systematically in ascending or descending order. This allows us to write better programs like indexing to fetch the information faster, allows faster search techniques, removes duplicate information and has many uses in statistical applications. Arranging numbers in ascending order is critical for highlighting significant values, optimizing processes, and enhancing the effectiveness of data analysis and presentation. This practical will help the students to develop skills to understand how to access data from external memory, use of branch instructions and arranging numbers in ascending order.

## II Industry/Employer expected outcome(s)

**Maintain microcontroller-based systems.**

### III Course Level Learning Outcome(s)

Develop program in 8051 in assembly language for the given operation.

## IV Laboratory Learning Outcome(s)

Develop an ALP for arranging numbers in ascending order stored in internal/external data memory.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

**Ascending order/Descending order**

The block of data consists of numbers in random order, to arrange these numbers in ascending or descending order bubble sort method is used.

If the given block of data has to be sorted in ascending order, then bubble sort will start by comparing the first element of the block with the second element, if the first element is greater than the second element, it will swap both the elements, and then move on to compare the second and the third element, and so on.

The different types of counters used in this process:

1. Byte counter –to access data from block of data
2. Pass counter –to repeat this comparison are required to arrange the numbers in ascending or descending order.

Branch instructions like

JNC—Jump if no carry

CJNE—Compare and jump if not equal to are used to sort the numbers.

## VII Resources Required

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1 | Desktop PC | Loaded with open-source IDE, simulation and program downloading software | 1 No. |

## VIII Precautions to be Followed

1. Check rules / syntax of assembly programming.

## IX Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL and select AT89C51.
5. Type the program in text editor and save as filename.asm extension.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window.
11. Note the values of the result of various operations in the observation table.

## E-Waste Management

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: **Write and execute a program to arrange the ten data values in external memory in descending order**

**Step 1-Algorithm**

Step 1: Initialize a counter for comparison (Pass counter).
Step2: Initialize memory pointer to read number from the array.
Step3: Initialize byte counter.
Step 4: Read numbers from array.
Step 5: Compare two numbers.

Step 6: If number less than or equal to next number, then go to step 8.
Step 7: Replace number with next number which is largest.
Step 8: Increment memory pointer to read next number in the array.
Step 9: Decrement byte counter by 1.
Step 10: If byte counter is not equal to zero then go to step 4.
Step 11: Decrement pass counter by 1.
Step 12: If pass counter is not equal to zero then go to step 2.
Step 13: Stop.

**Step 2-Flow Chart:**

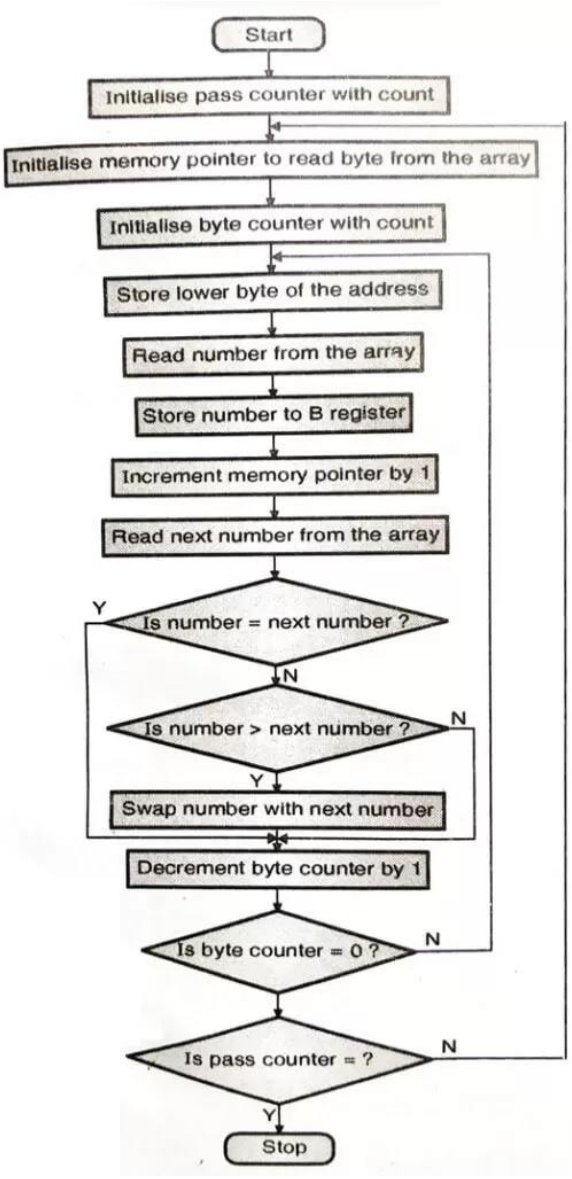


**Fig 11.1: Flowchart for Descending order**

**Step 3- Assembly Language Sample Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000h | |
| C:0x0000 | 7805 | | MOV R0, #0AH | ;Initialize pass counter |
| C:0x0002 | 904000 | REP1: | MOV DPTR, #4000H | ;Initialize memory pointer |
| C:0x0005 | 7904 | | MOV R1, #09H | ;Initialize byte counter |
| C:0x0007 | AA82 | REPEAT | MOV R2, DPL | ;Save the lower byte address |
| C:0x0009 | E0 | | MOVX A, @DPTR | ;Read number from array |
| C:0x000A | F5F0 | | MOV 0F0H, A | ;Transfer the number to B register |
| C:0x000C | A3 | | INC DPTR | ;Increment memory pointer |
| C:0x000D | E0 | | MOVX A, @DPTR | ;Read next number from array |
| C:0x000E | B5F002 | | CJNE A, 0F0H, NEXT | ;Compare number with next number |
| C:0x0011 | 011C | | AJMP SKIP | |
| C:0x0013 | 5007 | NEXT: | JNC SKIP | ;If number>next number then go to SKIP |
| C:0x0015 | 8A82 | | MOV DPL, R2 | ;Else exchange the number with next number |
| C:0x0017 | F0 | | MOVX @DPTR, A | |
| C:0x0018 | A3 | | INC DPTR | |
| C:0x0019 | E5F0 | | MOV A, 0F0H | |
| C:0x001B | F0 | | MOVX @DPTR, A | |
| C:0x001C | D9E7 | SKIP: | DJNZ R1, REPEAT | ;Decrement byte and if count byte is not zero go to Up |
| C:0x001E | D8E0 | | DJNZ R0, REP1 | ;Decrement pass counter and if not zero go to UP1 |
| | | | END | |

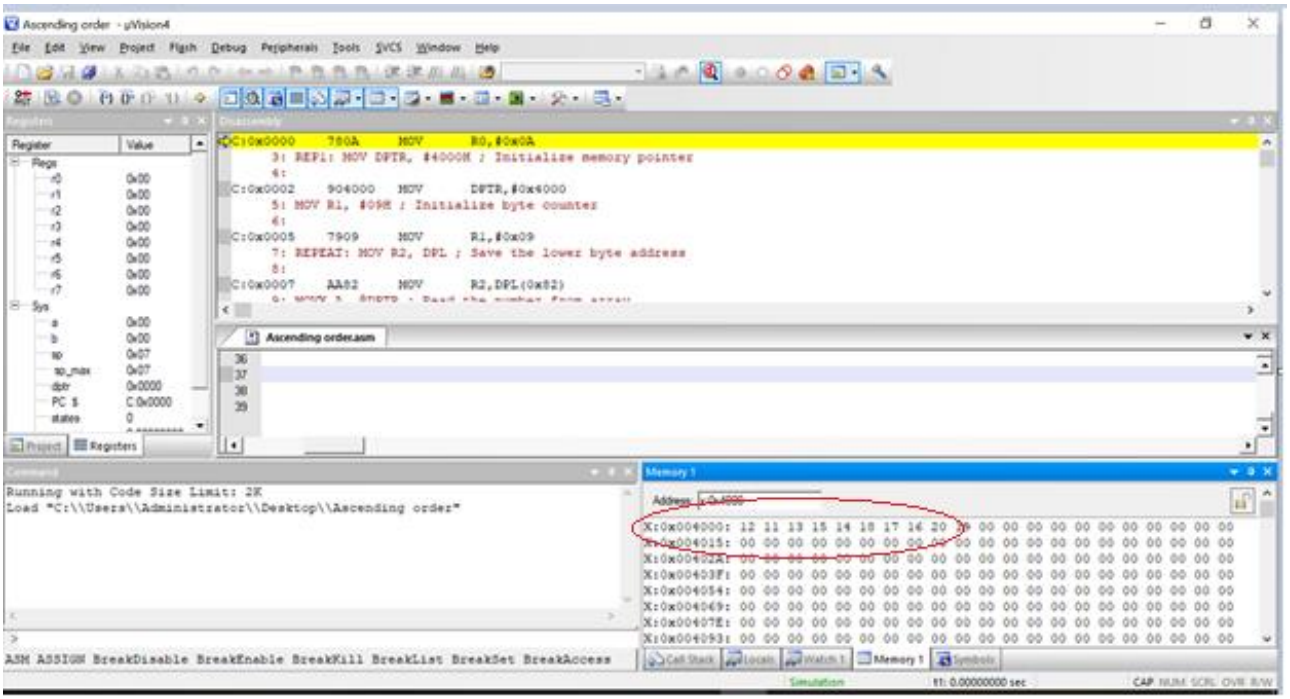


**Fig 11.2 Input Window**

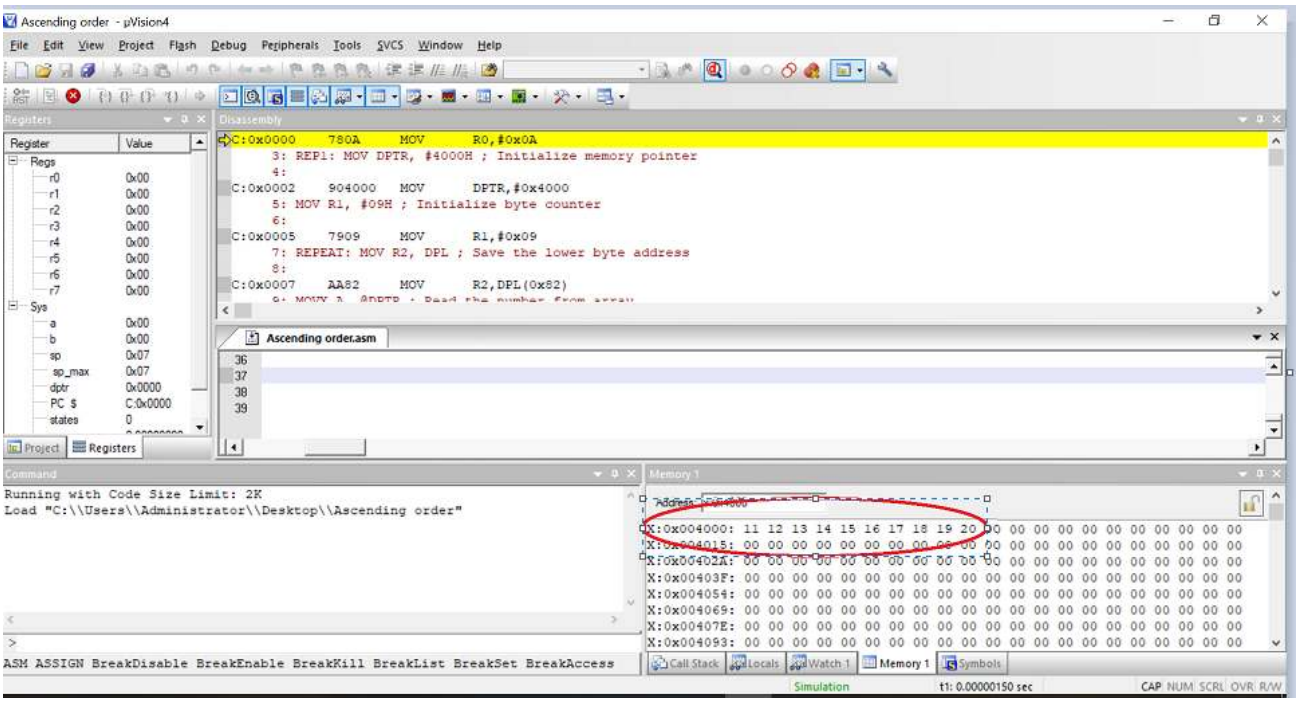


**Fig 11.3 Output Window**

**Problem statement 1 for student**: Write a program to arrange the numbers in ascending order. Assume internal memory locations.

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
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| Memory Address | Hex Code | Label | Mnemonics | Comments |
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**X Resources Used:**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
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**XI Actual Procedure Followed** (use blank sheet provided if space not sufficient)

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**XI Observations for sample program** (use blank sheet provided if space not sufficient)

| Before execution | | After execution | |
|---|---|---|---|
| Memory location | Data | Memory location | Data |
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**XV Results** (Output of the Program)

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**XVI Interpretation of Results (**Give meaning of the above obtained results)

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**XVII Conclusions and Recommendation (**Actions/decisions to be taken based on the interpretation of results).

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## XVIII Practical Related Questions

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

1. Explain the difference between CALL and JUMP instructions.
2. Give the difference between Long range jump and Absolute range.

**[Space for Answers]**

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## XIX References / Suggestions for further reading

1. https://electronicsforyou.in/8051-program-to-arrange-numbers-in-ascending-order/
2. https://technobyte.org/branching-instructions-8051/
3. https://instrumentationforindustry.com/programming-8051-microcontroller-sorting-arrays-algorithm/

## XX Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40% (10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 % (25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

## Practical No. 12: Arranging numbers in Descending order

## I Practical Significance

Sorting is any process of arranging information systematically in ascending or descending order. Helps in decision-making processes where resources are to be allocated based on priority, with the most critical or valuable cases handled first. Arranging numbers in descending order is critical for highlighting significant values, optimizing processes, and enhancing the effectiveness of data analysis and presentation. This practical will help the students to develop skills to understand how to access data from external memory and use of branch instructions.

## II Industry/Employer expected outcome(s)

**Maintain microcontroller-based systems.**

### III Course Level Learning Outcome(s)

Develop program in 8051 in assembly language for the given operation.

## IV Laboratory Learning Outcome(s)

Develop an ALP for arranging numbers in descending order stored in internal/external data memory.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

**Ascending order/Descending order**

The block of data consists of numbers in random order, to arrange these numbers in ascending or descending order bubble sort method is used.

If the given block of data has to be sorted in descending order, then bubble sort will start by comparing the first element of the block with the second element, if the first element is smaller than the second element, it will swap both the elements, and then move on to compare the second and the third element, and so on.

The different types of counters used in this process:

1. Byte counter –to access data from block of data
2. Pass counter –to repeat this comparison are required to arrange the numbers in ascending or descending order.

Branch instructions like

JNC—Jump if no carry

CJNE—Compare and jump if not equal to are used to sort the numbers.

## VII Resources Required

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1 | Desktop PC | Loaded with open-source IDE, simulation and program downloading software | 1 No. |

## VIII Precautions to be Followed

1. Check rules / syntax of assembly programming.

## IX Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL and select AT89C51.
5. Type the program in text editor and save as filename.asm extension.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window.
11. Note the values of the result of various operations in the observation table.

## E-Waste Management

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: **Write and execute a program to arrange the ten data values in external memory in descending order**

**Step 1-Algorithm**

**Algorithm:**

**Step 1**: Initialize a counter for comparison (Pass counter).

**Step2**: Initialize memory pointer to read number from the array.

**Step3**: Initialize byte counter.
**Step 4**: Read numbers from array.
**Step 5**: Compare two numbers.
**Step 6**: If number greater than or equal to next number, then go to step 8.
**Step 7**: Replace number with next number which is smaller.
**Step 8**: Increment memory pointer to read next number in the array.
**Step 9**: Decrement byte counter by 1.
**Step 10**: If byte counter is not equal to zero then go to step 4.
**Step 11**: Decrement pass counter by 1.
**Step 12**: If pass counter is not equal to zero then go to step 2.
**Step 13**: Stop.

**Step 2-Flow Chart:**

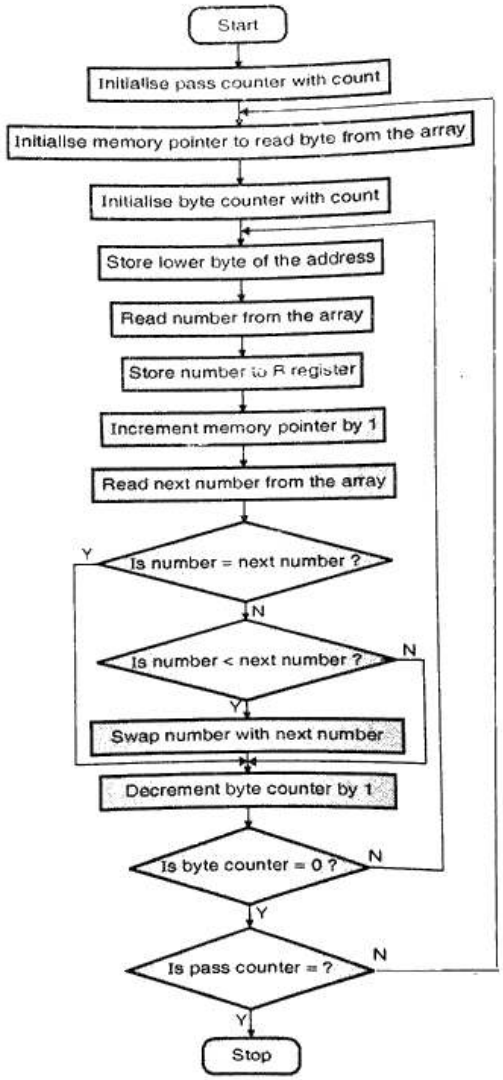


**Fig 12.1: Flowchart for Descending order**

**Step 3- Assembly Language Sample Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 00H | |
| C:0X0000 | 780A | | MOV R0, #0AH | Initialize pass counter. |
| C:0X0002 | 904000 | **REP1** | MOV DPTR, #4000H | Initialize memory pointer |
| C:0X0005 | 7909 | | MOV R1, #09H | Initialize byte counter |
| C:0X0007 | AA82 | **REPEAT** | MOV R2, DPL | Save the lower byte address |
| C:0X0009 | E0 | | MOVX A, @DPTR | Read the number from array |
| C:0X000A | F5F0 | | MOV 0F0H, A | Store the number in register B |
| C:0X000C | A3 | | INC DPTR | Increment memory pointer |
| C:0X000D | E0 | | MOVX A, @DPTR | Take the next number from array |
| C:0X000E | B5F002 | | CJNE A, 0F0H, NEXT | Compare number with next number |
| C:0X0011 | | | AJMP SKIP | Jump to SKIP unconditionally |
| C:0X0013 | 4007 | **NEXT:** | JC SKIP | If number < next number then go to skip |
| C:0X0015 | 8A82 | | MOV DPL, R2 | Else exchange the number with next number |
| C:0X0017 | F0 | | MOVX@DPTR, A | Copy greater number to memory locations |
| C:0X0018 | A3 | | INC DPTR | Increment memory pointer |
| C:0X0019 | E5F0 | | MOV A, 0F0H | |
| C:0X001B | F0 | | MOVX @DPTR, A | |
| C:0X001C | D9E9 | **SKIP:** | DJNZ R1, **REPEAT** | Decrement byte counter by 1, if byte counter≠ 0 then go to REPEAT. |
| C:0X001E | D8E2 | | DJNZ R0, **REP1** | Decrement pass counter if not zero then go to REP1 |
| C:0X0020 | 0120 | **STOP**: | AJMP **STOP** | STOP |
| | | | END | |

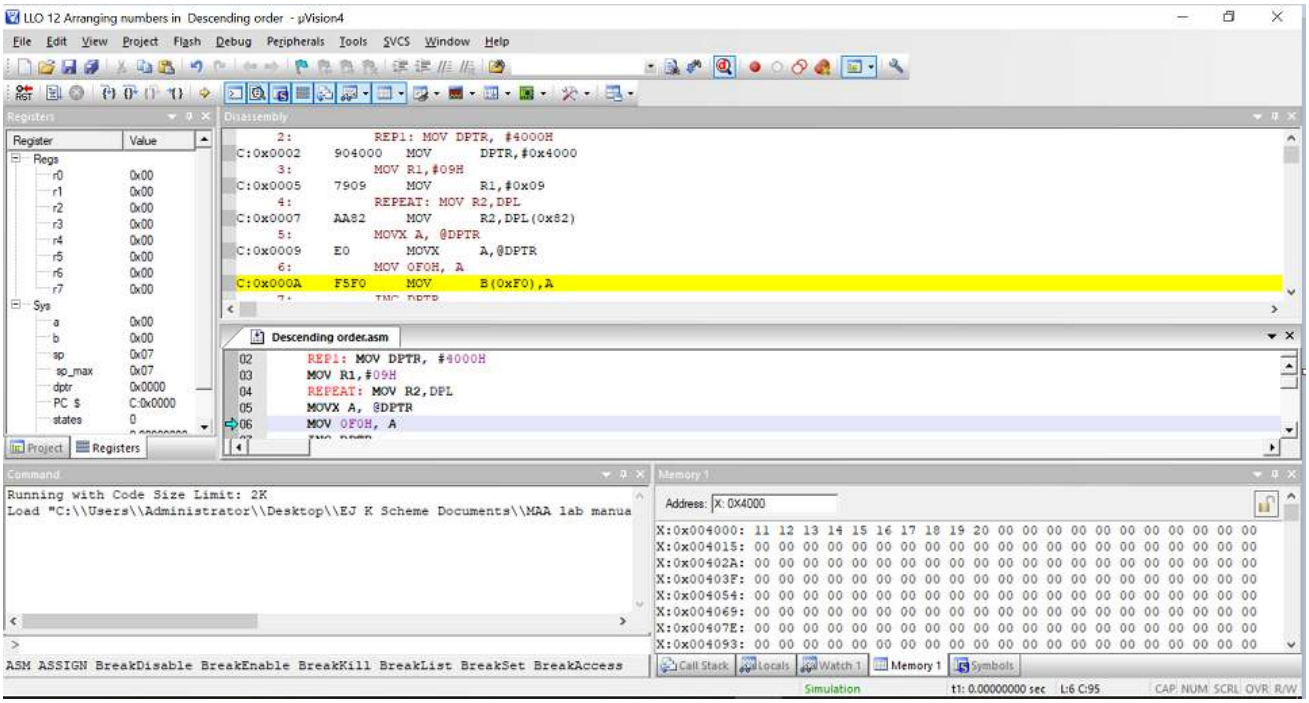


**Fig 12.2 Input Window**

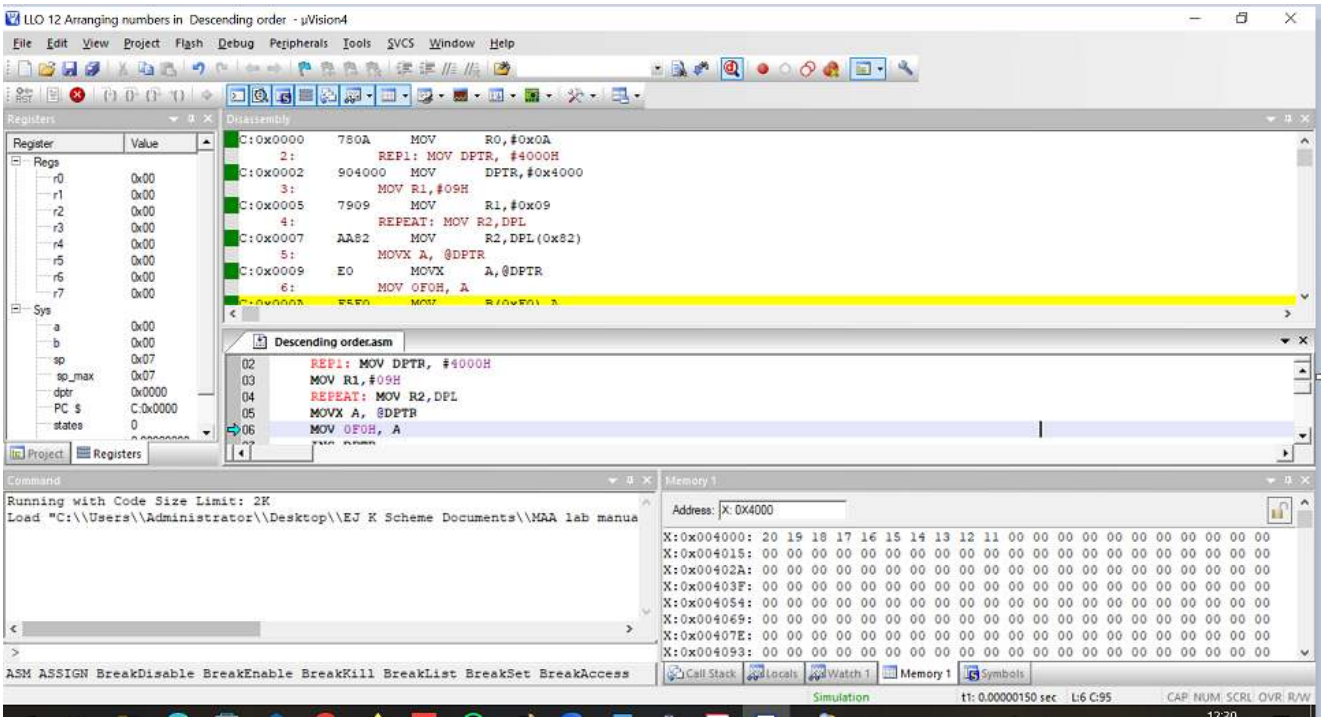


**Fig 12.3 Output Window**

**Problem statement 1 for student**: Write a program to arrange the numbers in descending order. Assume internal memory locations.

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
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| Memory Address | Hex Code | Label | Mnemonics | Comments |
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**X Resources Used:**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | | | |

**XI Actual Procedure Followed** (use blank sheet provided if space not sufficient)

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**XI Observations for sample program** (use blank sheet provided if space not sufficient)

| Before execution | | After execution | |
|---|---|---|---|
| Memory location | Data | Memory location | Data |
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**XV Results** (Output of the Program)

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**XVI Interpretation of Results (**Give meaning of the above obtained results)

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**XVII Conclusions and Recommendation (**Actions/decisions to be taken based on the interpretation of results).

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## XVIII Practical Related Questions

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

1. Give the significance of CJNE and DJNZ instructions.
2. Explain the different branch ranges used in 8051.
3. Give the difference between Long range jump and Short range jump.

**[Space for Answers]**

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## XIX References / Suggestions for further reading


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2. https://technobyte.org/branching-instructions-8051/
3. https://instrumentationforindustry.com/programming-8051-microcontroller-sorting-arrays-algorithm/


## XX Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40% (10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 % (25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 13: Generate delay using timer register

## I Practical Significance

Generation of time delay is most important concept in embedded systems. The purpose of the delay program is to introduce a pause or delay in program execution for a specified amount of time. Most of the times, precise time delay needs to be generated between two actions in microcontroller applications, like blinking of LED, Pulse generation, monitoring switch etc. We can generate the time delay using the Loop technique. Precise time delay can be generated using inbuilt timers in microcontroller. This practical will help the students to develop skills to create the time delay by using timer registers and microcontroller crystal frequency.

## II Industry/Employer Expected Outcome(s)

Maintain microcontroller based systems.

## III Course Level Learning Outcome(s)

Develop program using timers and interrupts

## IV Laboratory Learning Outcome(s)

Write an ALP to generate delay using timer register

## V Relevant Affective Domain related outcome(s)

Follow ethical practices.

## V I Relevant Theoretical Background

The 8051 microcontroller has two 16-bit timers/counters called Timer 0 and Timer1.
They can be used either as timers to generate a time delay or as counters to count the events.
Since the microcontroller 8051 has an 8-bit architecture, each 16-bit timer is accessed as two separate registers THx and TLx

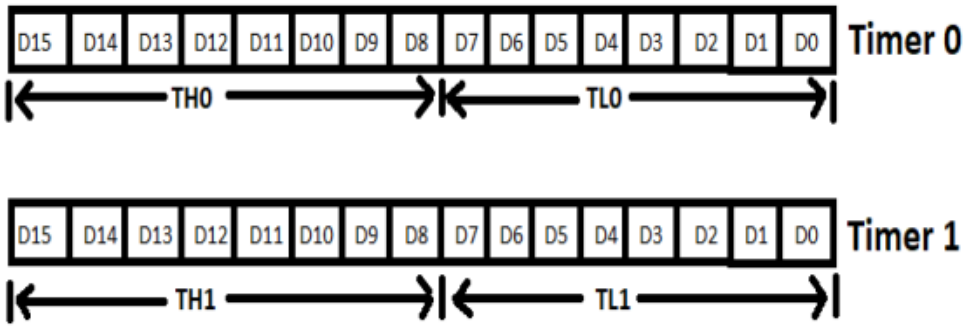


**Fig 13.1 Timer 0 / Timer 1**

**TMOD Register:**

TMOD register is used to select various timer operation modes for Timer 0 and Timer 1

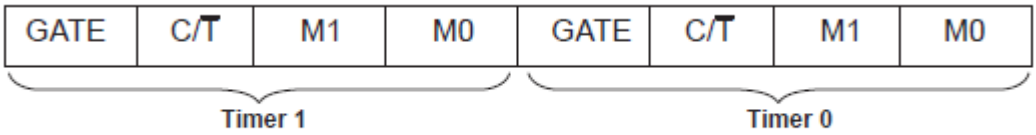


**Fig 13.2 TMOD Register**

**GATE** : When TRX (in TCON) is set and GATE=1 , TIMER/COUNTER will run only while INTX pin is high( hardware control), when GATE=0 , TIMER/COUNTER will run only while TRX=1 regardless of state of INTX pin (software control)

**C/T:** Timer or Counter Selector

**1 =** counter – external timing signal , input from T0/T1 pin

**0 =** timer – internal timing signal , input from internal system clock

**M1 M0** : These two bits selects the Time / Counter operating mode.

| M1 | M0 | MODE | DESCRIPTION |
|---|---|---|---|
| 0 | 0 | 0 | 13-bit timer/counter |
| 0 | 1 | 1 | 16 bit timer/counter |
| 1 | 0 | 2 | 8 bit auto-reload |
| 1 | 1 | 3 | Split mode:<br>(Timer 0) TL0 is an 8-bit timer/counter controlled by the standard timer 0 Control bits.<br>TH0 is an8-bit timer and is controlled by timer 1 control bits.<br>Timer1 / counter1 is stopped |

**TCON Register:**

TCON is 8 bit SFR used to control the Timer/Counter operations

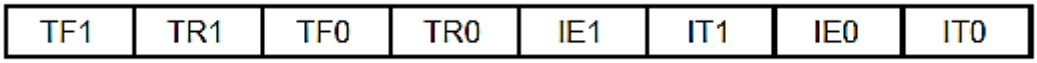


**Fig 13.3 TCON Register**

| Bit | Symbol | TCON Bit Function |
|---|---|---|
| 7 | TF1l | Timer 1 Overflow flag. Set when timer rolls from all 1's to 0. Cleared when processor vectors to execute interrupt service routine located at program address 001Bh. |
| 6 | TR1l | Timer 1 run control bit. Set to 1 by program to enable timer to count; cleared to 0 by program to halt timer. |
| 5 | TF0 l | Timer 0 Overflow flag. Set when timer rolls from all 1's to 0. Cleared when processor vectors to execute interrupt service routine located at program address 000Bh. |

| Bit | Symbol | TCON Bit Function |
|---|---|---|
| 4 | TR0l | Timer 0 run control bit. Set to 1 by program to enable timer to count; cleared to 0 by program to halt timer. |
| 3 | IE1 1 | External interrupt 1 Edge flag. Set to 1 when a high-to-low edge signal is received on port 3.3 (INT1'). Cleared when processor vectors to interrupt service routine at program address 0013h. Not related to timer operations. |
| 2 | IT1 1 | External interrupt 1 signal type control bit. Set to 1 by program to enable external interrupt 1 to be triggered by a falling edge signal. Set to 0 by program to enable a low-level signal on external interrupt 1 to generate an interrupt. |
| 1 | IE0 1 | External interrupt 0 Edge flag. Set to 1 when a high-to-low edge signal is received on port 3.2 (INT0'). Cleared when processor vectors to interrupt service routine at program address 0003h. Not related to timer operations. |
| 0 | IT0 1 | External interrupt 0 signal type control bit. Set to 1 by program to enable external interrupt 1 to be triggered by a falling edge signal. Set to 0 by program to enable a low-level signal on external interrupt 0 to generate an interrupt. |

**TIMER/COUNTER CONTROL LOGIC:**

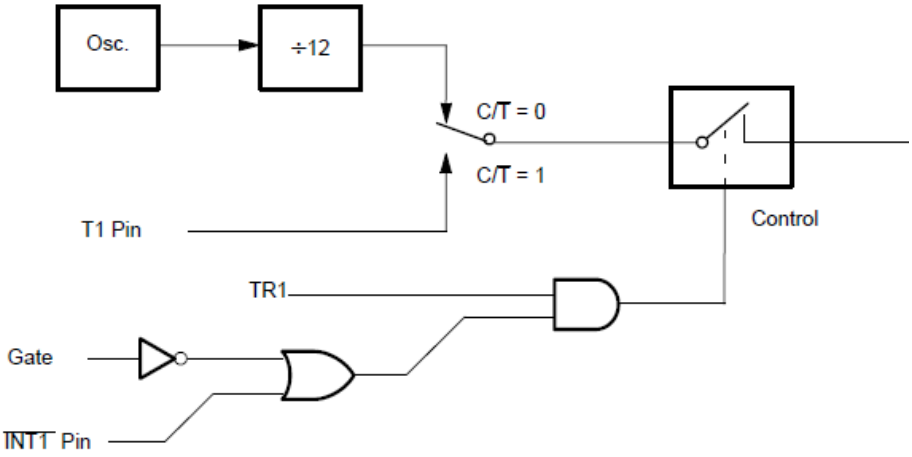


**Fig 13.4 Timer/Counter Logic**

**TIME DELAY GENERATION USING TIMER REGISTERS:**

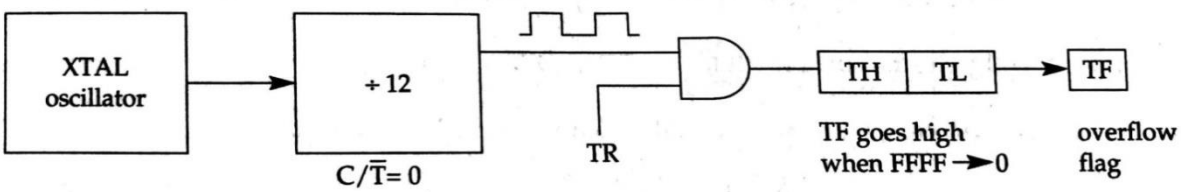


**Fig 13.5 Timer mode 1 diagram**

The Timer count increments by 1 at rate Fosc. / 12

So time for one increment is 12 / Fosc.

Therefore, if crystal frequency = 11.0592 MHz

∴ Counter frequency = $\frac{1}{12}$ × 11.0592 MHZ = 921.6 kHz

∴ Time for one increment = 12 / Fosc. = (12 / 11.0592MHz) = 1.085 μs

Time delay = Time for one increment x number of increments till overflow (N)

Time delay = (12 / Fosc) x number of increments (N)

Number of increments N till overflow = ($2^n$ – Initial count)

| Timer Mode | Value of n |
|---|---|
| Mode 0 | 13 |
| Mode 1 | 16 |
| Mode 2 | 8 |
| Mode 3 | 8 |

**10 ms Delay generation:**

Required time delay = 10 ms

Oscillator frequency is Fosc. = 11.0592MHz

**Time delay = (12 / Fosc) x number of increments (N)**

10 ms = (12 / 11.0592MHz) x number of increments (N)

10 ms = 1.085 μsec. x N

N = (10 x $10^{3)}$ μsec. / (1.085) μsec.

N = 9217

**INITIAL COUNT CALCULATION:**

Initial count = $2^n$ – N

Using TIMER MODE1 (n= 16)

Initial count = $2^{16}$ - N

= 65536 – 9217 = 56319 decimal = DBFF H

**THx = DBH ,**

**TLx = FFH**

## VII Required Resources/apparatus/equipment with specifications

| Sr . No. | Instrument /Components | Specification | uantity |
|---|---|---|---|
| 1. | Desktop PC | Loaded with open source IDE, simulation and program downloading software. | 1 No. |

## VIII Precautions to be followed

1) Check rules / syntax of assembly language programming.

## IX Procedure

1. Write algorithm for given problem.
2. Draw flowchart for the same.
3. Develop assembly program using Integrated Development Environment (Keil IDE) or any other relevant software tool.
4. Debug program on IDE.
5. Execute program on IDE.
6. Create hex file for the program.

7. Download hex code in EPROM/Flash memory of microcontroller.
8. Connect CRO probe to port pin and observe waveform.
9. Measure ON time and OFF time on CRO and draw the same in observation Table.

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM :** To toggle Port Pin P1.5 with 10ms delay using Timer

**Step 1: Algorithm**

1. Load the TMOD value register indicating which timer (Timer 0 or Timer 1) is to be used and which timer mode(0 or 1) is selected.
2. Load registers TL and TH with initial count values.
3. Start the timer.
4. Keep monitoring the timer flag (TF) with the "JNB TFx, target" instruction to see if it is raised. Get out of the loop when TF becomes high.
5. Stop the timer.
6. Toggle Port pin high and low
7. Clear the TF flag for the next round.
8. Go back to Step 2 to load TH and TL again.

**Step 2: Flowchart**

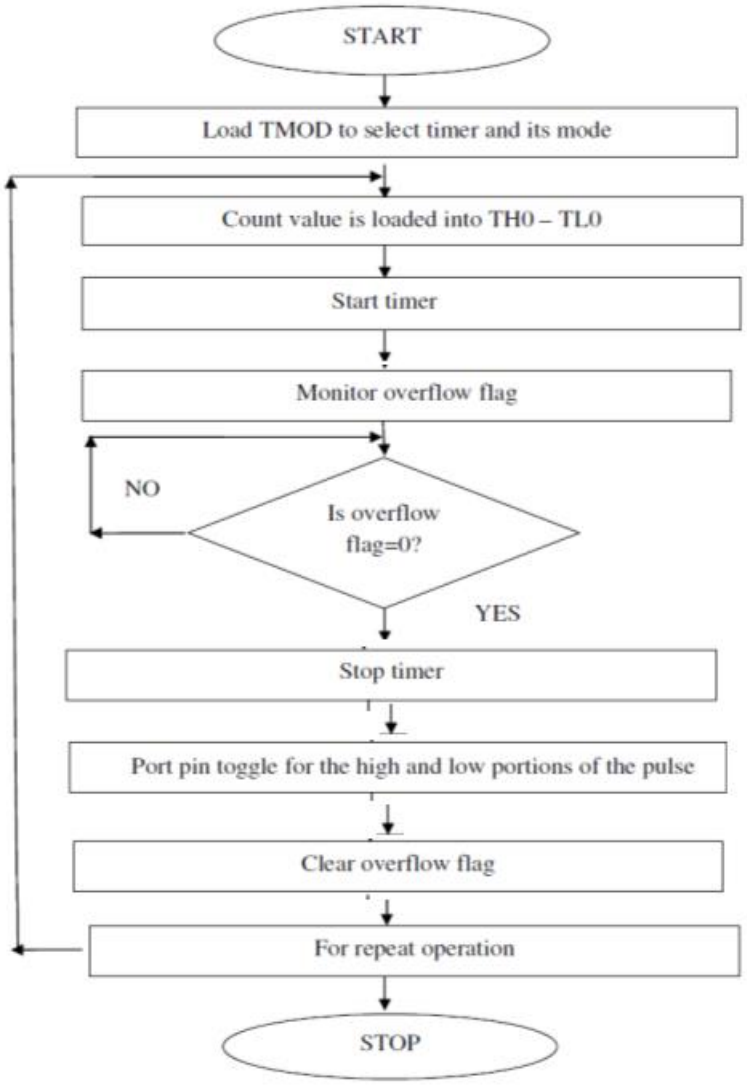


**Fig 13.8 Flowchart for toggling port pin**

**Step 3: Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | |
| C:0x0000 | 758901 | | MOV TMOD ,#01H | ;Timer 0, mode 1 |
| C:0x0003 | 758AFF | REPEAT: | MOV TL0,#0FFH | ;TL0=FFH |
| C:0x0006 | 758CDB | | MOV TH0,#0DBH | ;TH0=DBH |
| C:0x0009 | D28C | | SETB TR0 | ;start Timer 0 |
| C:0x000B | 308DFD | AGAIN: | JNB TF0, AGAIN | ;monitor Timer 0 overflow flag until it rolls over |
| C:0x000E | C28C | | CLR TR0 | ;stop Timer 0 |
| C:0x0010 | B295 | | CPL P1.5 | ;toggle P1.5 |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x0012 | C28D | | CLR TF0 | ;clear Timer 0 flag |
| C:0x0014 | 80ED | | SJMP REPEAT | ;Reload TH, TL again |

## Output Window

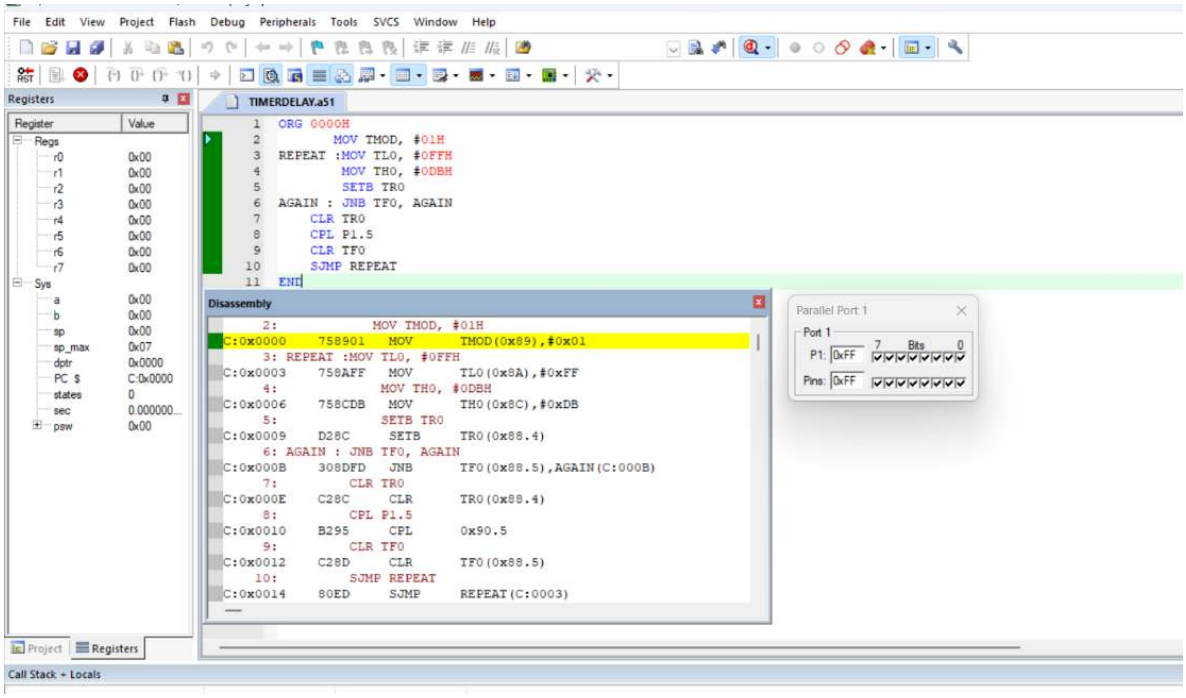


**Fig: 13.9 Output Window**

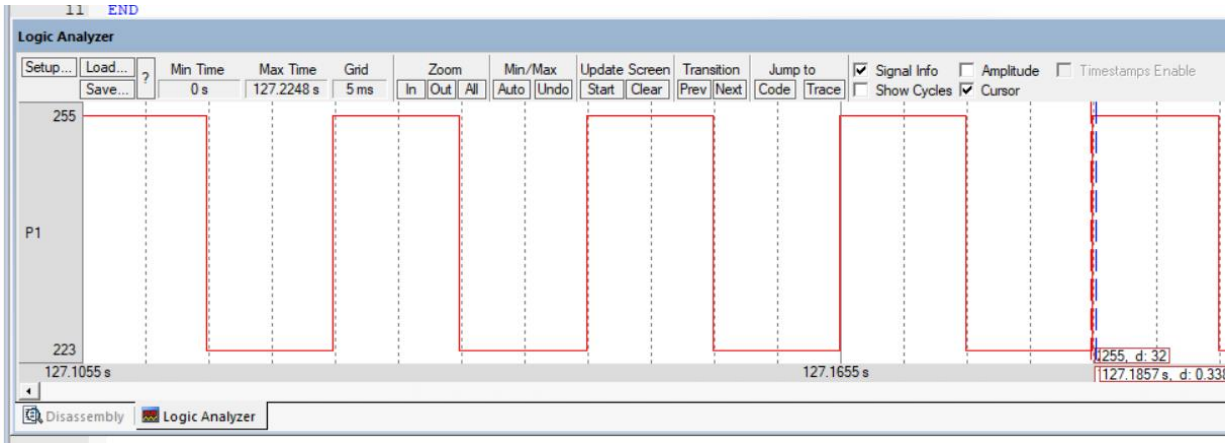


**Fig 13.10: Waveform Output**

**Problem statement for student:** Write a program to toggle Port 2 Pins with 25ms delay using Timer 1 Mode 1. Assume XTAL = 11.0592MHz

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | | |
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**X Resources used**

| Sr. No. | Name of Resource | Specifications | Quantity |
|---|---|---|---|
| | | | |
| | | | |

**XI Actual Procedure Followed** (use blank sheet provided if space not sufficient)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……

**XII Observations for problem statement** (use blank sheet provided if space not sufficient)

Draw Square wave and show TON and TOFF time

**XIII Results (Output of the Program)**

……

……

**XIV Interpretation of Results (Give meaning of the above obtained results)**

……..…

…….

**XV Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

……..……..

……..……..

**XVI Practical related questions**

***Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.***

1. To get a 5 ms delay, what number should be loaded into TH, TL using mode 1. Assume XTAL= 11.0592MHz.
2. Explain Timer Mode 2 Operation.

**[Space for Answers]**

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## XVII References/Suggestions for further reading


1. http://nptel.ac.in/courses/Webcourse-contents/IIT-KANPUR/microcontrollers/micro/ui/Course_home2_8.htm
2. http://www.circuitstoday.com/8051-timers-counters.
3. The 8051 Microcontroller and Embedded system Using Assembly and C- Muhammad Ali Mazidi, Janice Gillispie Mazidi, Rolin D. Mckinlay- Pearson /Prentice Hall, , 2nd edition, Delhi,2008, ISBN 978-8177589030.


## XVIII Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 14: Serial 8-bit data transfer on serial port

## I Practical Significance

Many applications require microcontrollers to either accept the data in serial form or output the data in serial form. Serial communication is commonly used in applications such as industrial automation systems, scientific analysis and certain consumer products. This practical will help the students to develop skills to understand the concepts of serial port and serial 8 bit data transfer.

## II Industry/Employer Expected Outcome(s)

Maintain microcontroller-based systems.

## III Course Level Learning Outcome(s)

Develop program using timers and interrupts

## IV Laboratory Learning Outcome(s)

Develop an ALP to transfer 8-bit data serially on serial port.

## V Relevant Affective Domain related outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

Serial communication is the process of sending data one bit at a time, sequentially, over a communication channel. There are two methods of serial communication:

1) Synchronous: Transfer of block of data at a time
2) Asynchronous: Transfer of one byte (character) at a time

One of the major differences is that in Synchronous Transmission, the sender and receiver should have synchronized clocks before data transmission. Whereas Asynchronous Transmission does not require a clock, but it adds a parity bit to the data before transmission.

### 1. Synchronous data transfer.

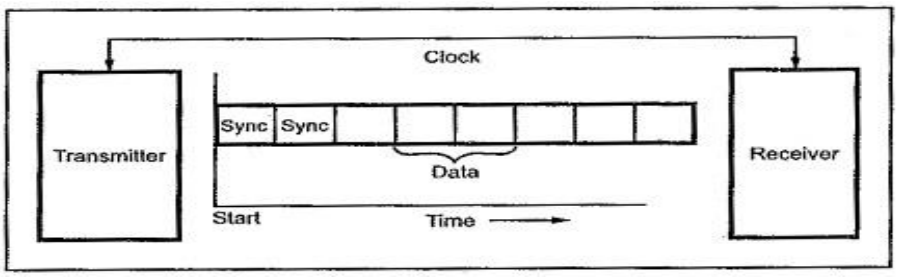


**Fig. 14.1 Synchronous data transfer**

**2. Asynchronous data transfer.**

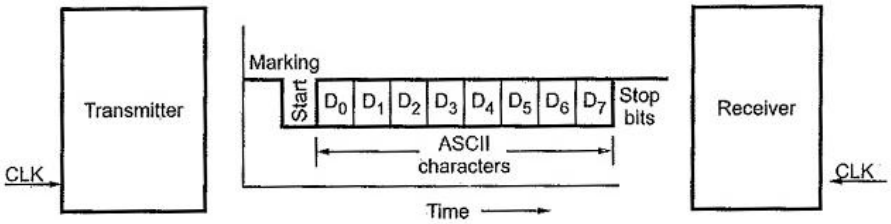


**Fig. 14.2 Asynchronous data transfer**

**Baud Rate**

In serial communication the rate at which data bits are transmitted generates a term baud rate, the baud rate is defined as bits/seconds or the changes in voltage levels/second.
Standard baud rates are 1200, 2400, 4800, 9600, 14400, 19200 bits per second(bps)

**Serial Port of 8051:**

8051 has a built-in full duplex 8-bit UART(Universal Asynchronous Transmitter Receiver)

**SCON REGISTER:**

Serial control (SCON) is an 8-bit register used to control the 8051 Microcontroller's Serial Port.

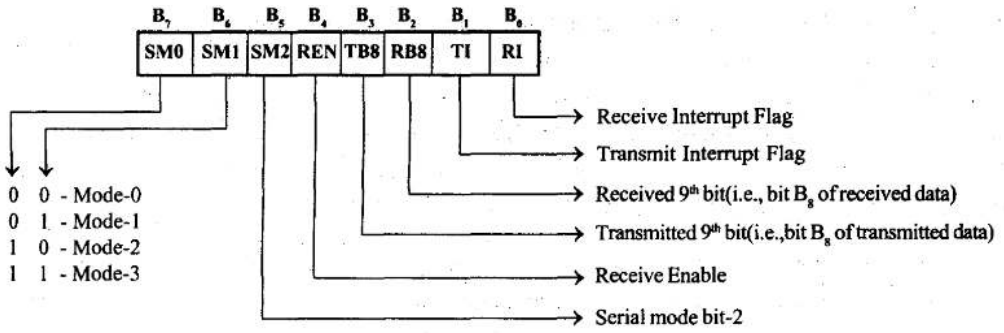


**Fig. 14.3 SCON register format**

**SBUF Register**

SBUF is a 8 bit register used in serial communication of 8051. Serial data is sent by writing to the register SBUF while data is received by reading the same register. SBUF has physically two registers, one write only and other is read only. Both registers use one address 99H

**Baud Rate Generation:**

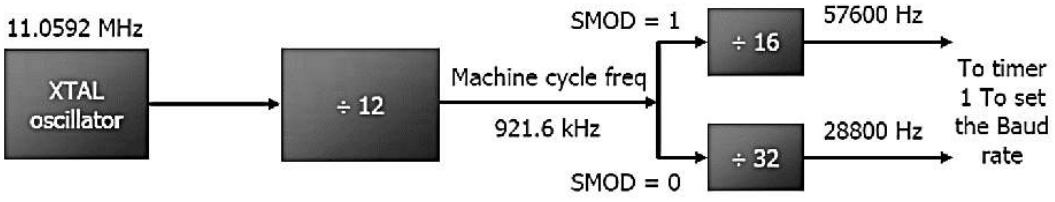


**Fig. 14.4 Baud Rate generation**

Timer 1, in mode 2 (8-bit, auto-reload) to generate baud rate

$$\text{Baud Rate} = \frac{2^{SMOD}}{32} \times (\text{Timer 1 Overflow Rate})$$

$$\text{Baud Rate} = \frac{2^{SMOD}}{32} \times \frac{\text{Oscillator Frequency}}{12 \times [256 - (\text{TH1})]}$$

**Table No: 14.1 Values of Timer 1 Register for various Baud Rates**

| Baud Rate | | TH1(Decimal) | TH1(Hex) |
|---|---|---|---|
| SMOD=0 | SMOD=1 | | |
| 9600 | 19200 | -3 | FDH |
| 4800 | 9600 | -6 | FAH |
| 2400 | 4800 | -12 | F4H |
| 1200 | 2400 | -24 | E8H |

*Note:* XTAL = 11.0592 MHZ.

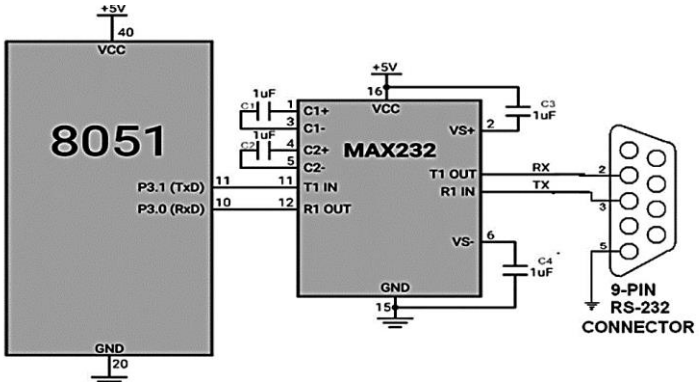


**Fig. 14.5 8051 Connection to the RS232 using MAX 232**

## VII Required Resources/apparatus/equipment with specifications

| Sr . No. | Instrument /Components | Specification | uantity |
|---|---|---|---|
| 1 | Microcontroller kit | Single board systems with 8K RAM, ROM memory with battery back up,16X4,16 X2, LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler, RS-232, USB, interfacing facility with built in power supply. | 1 No. |
| 2. | Desktop PC | Loaded with open source IDE, simulation and program downloading software. | 1 No. |

## VIII Precautions to be followed

1) Check rules / syntax of assembly language programming.

## IX Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL or INTEL and select 80c51AH 0r AT89C51.
5. Type the program in text editor and save as .asm or .a51.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window. It will display all internal registers of 8051 and their contents. The output can be observed in UART1 window.
11. Hyper Terminal, a Windows XP application, can be used to receive or transmit serial data through RS232. To open Hyper Terminal, go to Start Menu, select all programs, go to Accessories, click on Communications and select Hyper Terminal.
12. To start a new connection, go to File menu and click on new connection. The connection window opens up. Give a name to your connection and select 1st icon and click on OK. Connection property window opens here. Select Bit rate as 9600bps, Data bits 8, Parity as none, stop bit 1, Flow control none and click OK. Now the serial data can be read on hyper terminal.
13. In program, Timer1 is used with auto reload setting. The baud rate is fixed to 9600bps by loading TH1 to 0xFD. The value 0x50 is loaded in the SCON register. This will initialize the serial port in Mode1. The program continuously transmits a character (say 'A') from 8051serial port to Serial port of the computer.

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM:** Write an ALP to transfer 8-bit data serially on serial port.

**Step 1: Algorithm**

1. Initialize TMOD register for Timer1, Mode2 and its mode.
2. Load the value in the timer register corresponding to the 9600 baud rate.
3. Load SCON with 50H value indicating mode 1, 1 stop and start bit.
4. Set the timer run bit to start Timer 1

5. Load the character ‘A’ in SBUF.
6. Check TI to determine whether the transmission process is completed.
7. Clear TI flag for the next character.
8. Stop

**Step 2: Flowchart**

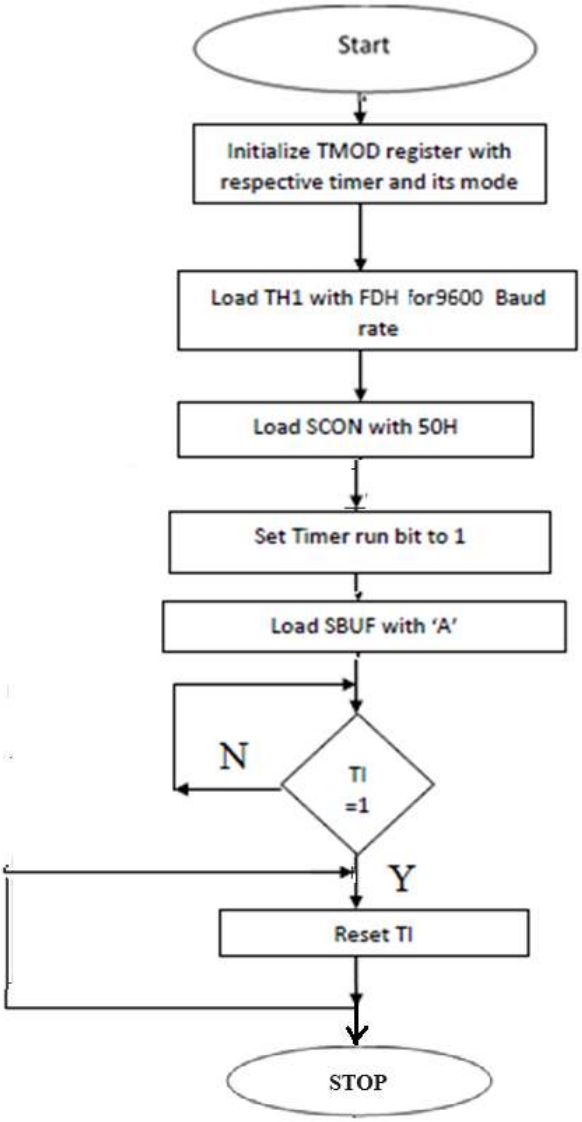


**Fig 14.6 Flowchart for 8-bit data serial data transfer**

**Step 3: Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x0000 | 758920 | | MOV TMOD, #20H | ;Timer 1,mode 2 |
| C:0x0003 | 758DFD | | MOV TH1, # -3 | ;9600 baud rate |
| C:0x0006 | 759850 | | MOV SCON, #50H | ;8 bit,1 stop Bit, REN enabled |
| C:0x0009 | D28E | | SETB TR1 | ;Start Timer 1 |
| C:0x000B | 759941 | HERE: | MOV SBUF, #’A’ | ;Character ‘A’ to be transferred |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x000E | 3099FD | WAIT: | JNB TI, WAIT | ;Wait for the last bit |
| C:0x0011 | C299 | | CLR TI | ;Clear TI for next character |
| C:0x0013 | 80F6 | | SJMP HERE | ;Wait |
| | | | END | |

## Output Window

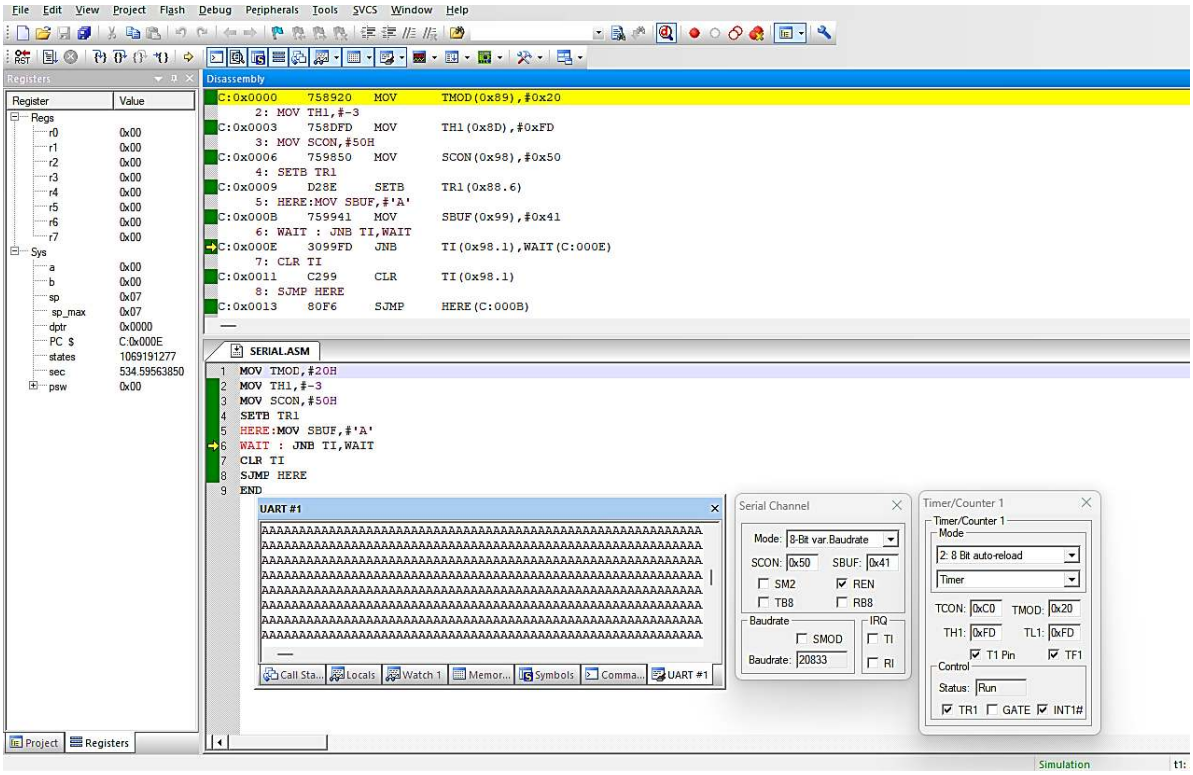


**Fig 14.7 Output Window**

**Problem statement for student:** Write a program to transfer message “MAA” at baud rate 4800 bps

| Step 1-Algorithm | Step 2-Flowchart |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | | |
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**X Resources used**

| Sr. No. | Name of Resource | Specifications | Quantity |
|---|---|---|---|
| | | | |
| | | | |

**XI Actual Procedure Followed** (use blank sheet provided if space not sufficient)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……

**XII Observations for problem statement** (use blank sheet provided if space not sufficient)
(UART window)

**XIII Results (Output of the Program)**

……

……

**XIV Interpretation of Results (Give meaning of the above obtained results)**

……..…

…….

**XV Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

……..……..

……..……..

**XVI Practical related questions**

***Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.***

1. State serial communication modes of 8051 along with their baud rate.
2. State SFRs used for Serial communication in 8051.
3. State significance of TI and RI flag in Serial communication

**[Space for Answers]**

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## XVII References/Suggestions for further reading

1. https://embetronicx.com/tutorials/tech_devices/serial-communication-basics-tutorial-for-beginners/
2. https://ebooks.inflibnet.ac.in/csp13/chapter/serial-port-communication/
3. https://www.codrey.com/embedded-systems/serial-communication-basics/
4. https://www.electronicwings.com/8051/8051-uart

## XVIII Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 15: LED interfacing to 8051

## I Practical Significance

LED is most common semiconductor device used in many electronic system as visual indicator or signal transmission / power indication purposes. The LEDs are also used for design message display boards and traffic control signal lights etc. Interrupts are most important feature of Microcontroller. This practical will help the students to develop skills to understand the fundamental interfacing concept for 8051 microcontrollers and significance of Interrupts.

### II Industry/Employer expected Outcome(s)

Maintain microcontroller- based systems

### III Course Level Learning Outcome(s)

Interface memory and I/O peripherals to 8051 microcontroller.

### IV Laboratory Learning Outcome

Interface LED with microcontroller and turn it "ON" with microcontroller interrupt.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

The 8051 microcontroller features four bidirectional I/O ports, each consisting of 8 bits, which can be used either as input or output. Here's a brief overview of each port:

1. **Port 0 (P0)**: This port can serve as both an input or an output port. When used as an output port, it provides open-drain outputs and requires pull-up resistors to operate as high (logic 1). Port 0 is also multiplexed with the lower order address and data bus during accesses to external memory.
2. **Port 1 (P1)**: Unlike Port 0, Port 1 does not need pull-up resistors because it has internal pull-ups. When the pins are used as inputs, they are held high by these internal pull-ups and can easily be interfaced with switches.
3. **Port 2 (P2)**: Similar to Port 1, this port also features internal pull-ups and serves dual purposes: it acts as a simple I/O port or, during external memory operations, it outputs the high-order address byte.
4. **Port 3 (P3)**: Port 3 has multiple functions besides serving as a general I/O port. Each pin on Port 3 can also be used for special functions like interrupts, serial communication, timer inputs, and read/write operations for external memory.

**Interrupt** is a subroutine call that interrupts microcontrollers main operations or work and causes it to execute any other program, which is more important at the time of operation. The feature of Interrupt is very useful as it helps in case of emergency operations. An Interrupts gives us a mechanism to put on hold the ongoing operations, execute a subroutine and then again resume its original task.

1. Generally five interrupt sources are there in 8051 Microcontroller. Out of these, $\overline{\text{INT0}}$ and $\overline{\text{INT1}}$ are external interrupts that could be negative edge triggered or low level triggered. They are located on pins P3.2 and P3.3of port 3 respectively. They are enabled or disabled using the IE register when the external interrupt flag is edge triggered, the CPU clears

interrupt flag in response to the interrupt call. When it is level triggered then the interrupt flag is cleared at high level of the interrupt signal.

2. The table shows the vector addresses for the interrupts:

| Interrupt | Flag | Vector |
|---|---|---|
| System reset | RST | 0000H |
| External interrupt 0 | IE0 | 0003H |
| Timer 0 | TF0 | 000BH |
| External interrupt 1 | IE1 | 0013H |
| Timer 1 | TF1 | 001BH |
| Serial port | RI or TI | 0023H |

**Light emitting diodes**: LEDs are the most commonly used components in many applications. It has two terminals positive and negative as shown in the figure:

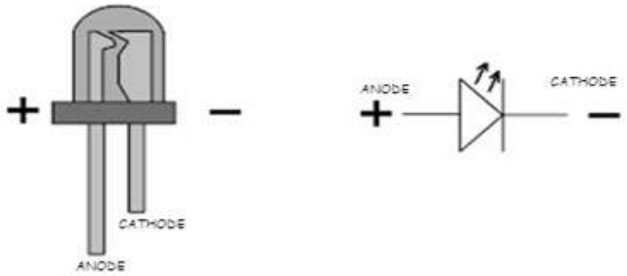


**Fig 15.1 LED diagram**

Commonly used LEDs will have voltage drop of 1.9v to 2.1v and current of 15mA (Typically) or 20mA(high brightness) to glow at full intensity. This is applied through the output pin of the microcontroller.

## VII Actual Circuit diagram used in laboratory with related equipment rating

a) Sample Circuit diagram

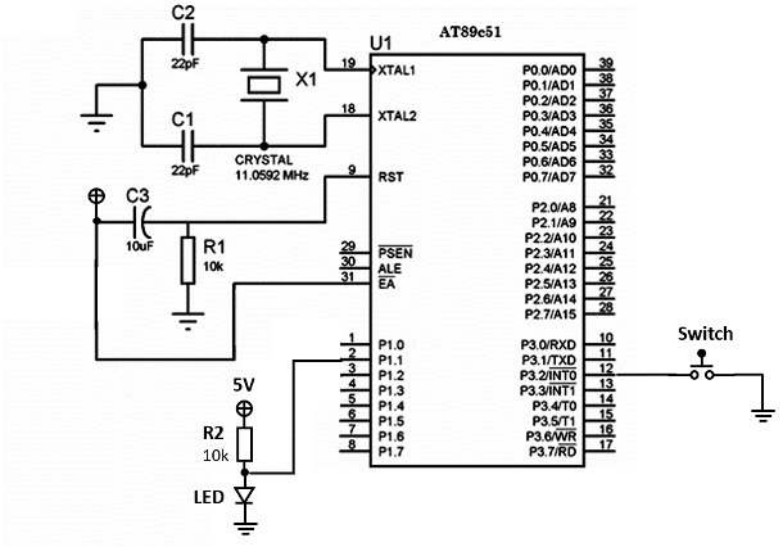


**Fig 15.2 8051 connection to LED and switch**

b) Practical setup

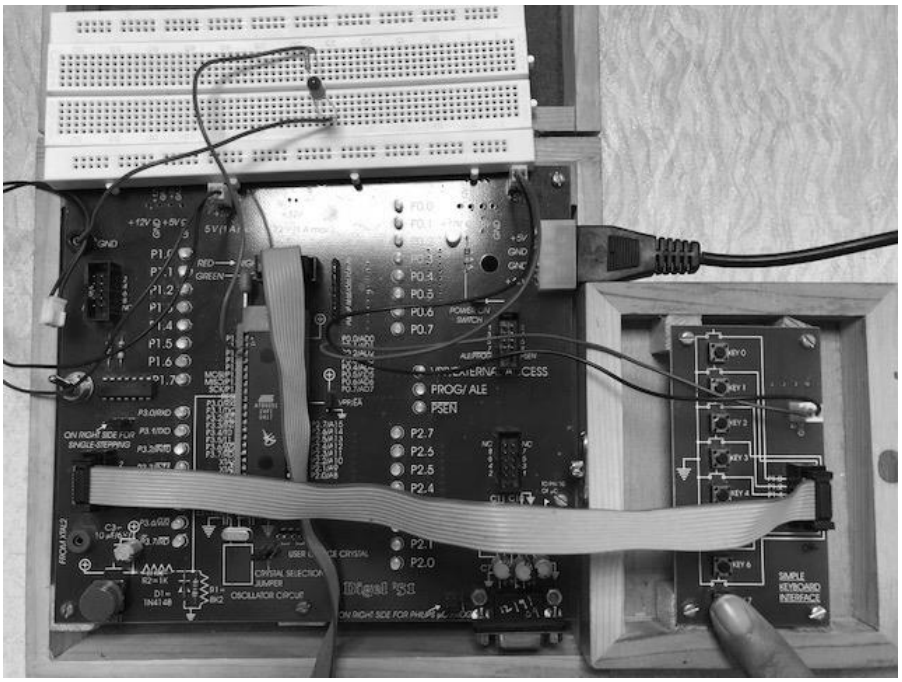

**Fig 15.3 Practical Setup**

c) Simulation diagram

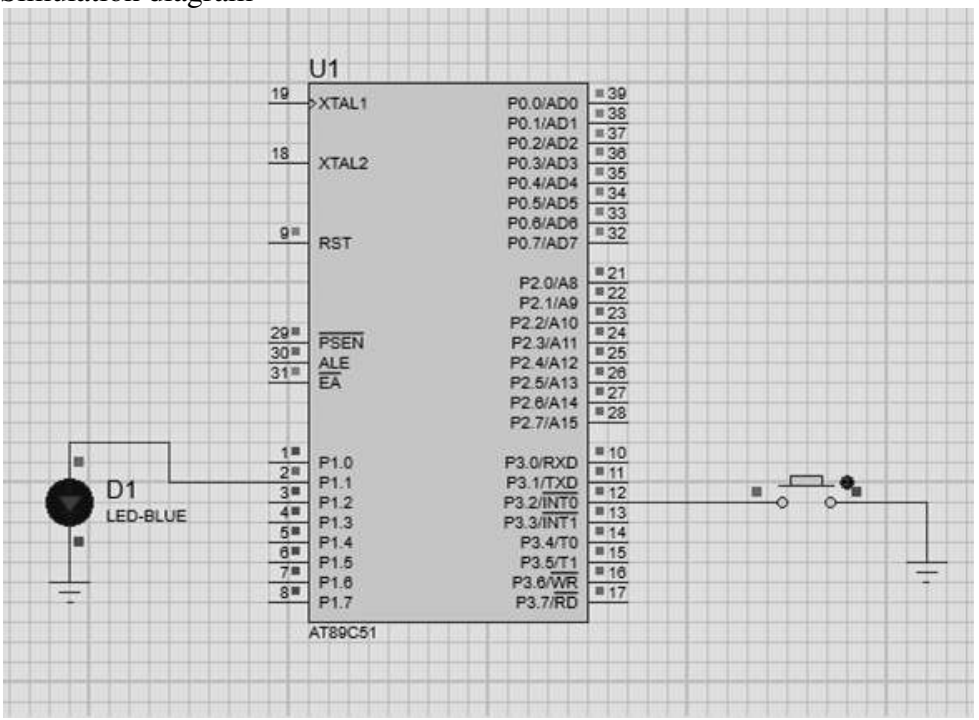


**Fig 15. 4 Simulation diagram**

d) Actual circuit used in Laboratory

e) Actual Experimental set up used in laboratory

## VIII Resources Required

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Microcontroller kit | Single board system with 8K RAM, ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler, RS-232, USB, interfacing facility with built in power supply. | 1 No. |
| 2. | Desktop PC | Loaded with open-source IDE, simulation and program downloading software. | 1 No. |

## IX Precautions to be followed

1. Use always current limiting resistor before LED connected to microcontroller

## X Procedure

1. Write algorithm for given problem.
2. Draw flowchart for the same.
3. Develop assembly program using Integrated Development Environment (Keil IDE) or any other relevant software tool.
4. Debug program on IDE.
5. Execute program on IDE.
6. Create hex file for the program.
7. Download hex code in EPROM/Flash memory of microcontroller.
8. Interface LED to microcontroller as per circuit diagram shown in fig.
9. Observe the LED to glow when external interrupt occurs on P3.2.

## E-Waste Management

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1:** Interface LED with microcontroller and turn it ON with microcontroller interrupt.

**Step 1: Algorithm**

**Main Program**

1. Initialize port P1 as output.
2. Initialize port P3 as input.
3. Clear pin P1.1
4. Enable interrupt INT0.
5. Wait for Interrupt.

**INT0 ISR**

1. Set pin P1.1
2. Return from ISR

**Step 2: Flowchart**

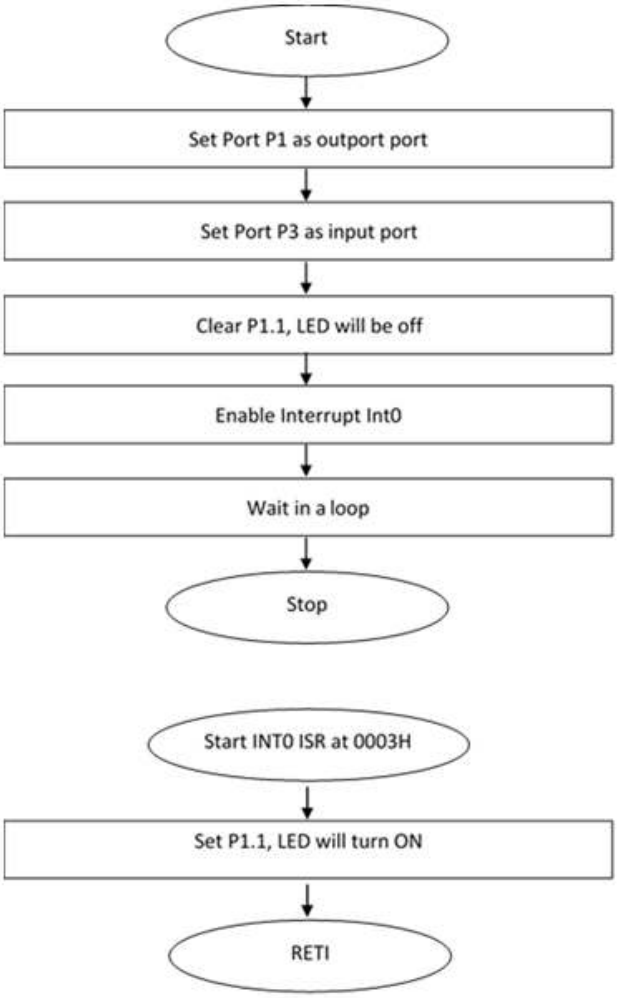


**Fig 15 .6 Flowchart to turn LED ON with microcontroller interrupt.**

**Step 3: Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | |
| C:0x0000 | 020006 | | LJMP START | |
| | | | ORG 0003H | Interrupt service routine for INTo |
| C:0x0003 | D291 | | SETB P1.1 | |
| C:0x0005 | 32 | | RETI | |
| C:0x0006 | 759000 | START: | MOV P1, #00H | Main program for initialization |
| C:0x0009 | 75B0FF | | MOV P3, #0FFH | |
| C:0x000C | 75A881 | | MOV IE, #81H | Enable hardware interrupt INT0 |
| C:0x000F | 80FE | HERE: | SJMP HERE | |
| | | | END | |

**Problem statement for student** Interface two LEDs with microcontroller and turn them ON with microcontroller interrupts.

| **Step 1: Algorithm** | **Step 2: Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | | |
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**XI Resources Used**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |

**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……

**XIII Observations** (use blank sheet provided if space not sufficient)

LED will become _____ (ON/OFF) after occurrence of_____ (INT0/INT1) Interrupt

**XIV Result** (Output of the Program)

……..

……..……..

**XV Interpretation of Results (**Give meaning of the above obtained results)

……..

……..……

**XVI Conclusions and Recommendation (**Actions/decisions to be taken based on the interpretation of results)

……

……..……

## XVII Practical Related Questions

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

1. Give the alternative functions of port 3.
2. Enlist the functions of Buffer, Tristate buffer.
3. Write a program to make all pins of Port 1 as input port and transfer its contents to Port 2.

**[Space for Answers]**

## XVIII References / Suggestions for further reading

1. https://vision-pi.net/common-cathode-vs-common-anode-led/
2. https://www.fypsolutions.com/assembly-language/8051-8052/led-blink-8051-assembly/
3. https://www.elprocus.com/led-interfacing-with-8051-microcontroller/

## XIX Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| | Performance indicators | Weightage |
|---|---|---|
| | **Process related (15 Marks)** | **60% (15)** |
| 7 | Coding and Debugging ability | 30% |
| 8 | Making connections of hardware | 20% |
| 9 | Follow ethical practices. | 10% |
| | **Product related (10 Marks)** | **40%(10)** |
| 10 | Correctness of algorithm/ Flow chart | 20% |
| 11 | Relevance of output of the problem definition. | 15% |
| 12 | Timely Submission of report, Answer to sample questions. | 05% |
| | **TOTAL** | **100% (25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 16: Generating Pulse and Square wave using timer delay

## I Practical Significance

The input/output (I/O) ports allow the microcontroller to connect to external devices and peripherals. In 8051 timers are used to generate delays or as counters to count events happening outside the microcontroller. In time required applications two available 16-bit timers are operated in different modes to generate specific delay. This practical will help the students to develop skills to program timers and generate delays for generating square wave on I/O port pin.

## II Industry/Employer Expected Outcome(s)

Maintain microcontroller based systems.

## III Course Level Learning Outcome(s)

Interface the memory and I/O peripherals to 8051 microcontroller

## IV Laboratory Learning Outcome(s)

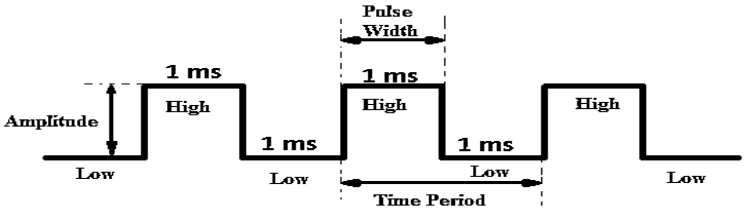
Develop an ALP to generate pulse and square wave by using timer delay.

## V Relevant Affective Domain related outcome(s)

Follow ethical practices.

## V I Relevant Theoretical Background

Square wave of any frequency (limited by the controller specifications) can be generated using the 8051 timer. Square wave generation requires a port pin to output logic high (‘1’) and logic low (‘0’) level alternately with delay in between. The delay time is equal to half of time period of square wave.




Time Period = (1+1)ms = 2ms

$$\text{Duty Cycle} = \frac{\text{Pulse width}}{\text{Time Period}} \text{ X } 100$$

$$= \frac{1}{2} \text{ X } 100$$

$$= 50\%$$

**Fig 16.1 Square Wave calculation**

Frequency = 1/ Time Period = 1/2ms = 0.5KHZ = 500HZ

Port pin can be toggled by using instruction CPL bit-address and /or by setting and resetting the port pin by using instruction SETB bit-address and CLR bit address respectively.

Square wave can be generated on port pin of microcontroller 8051 with precise TON and TOFF time by using Timers to generate delay. The frequency of the square wave generated depends on the count value loaded in timer registers and frequency of oscillator. 8051 has two timers, Timer 0 and Timer 1. Both are 16 bit up-counter. Timers operate in four modes. Timer count Increments at the rate of (Fosc./12) ,which is 1 machine cycle. After roll-over timer overflow flag is set

To generate a Pulse / square wave of a particular pulse width , the delay time equal to pulse width has to be generated using Timer.

**Generation of Pulse width delay using Timer Mode 1:**

Required time delay = ( 12/Fosc ) x number of increments (N)
1 ms = ( 12/ 11.0592MHZ ) x number of increments (N)
1 ms = 1.085 usec. x N
N = 1ms /1.085usec.
N =921.65 = 922
Using Timer MODE 1,
COUNT = $2^{16}$ - N
COUNT = 65536 – 922
COUNT = $(64614)_{10}$ = FC66H
Therefore THx = FCH
TLx = 66H

**Generation of 2 KHZ Square wave of 50 % duty cycle**

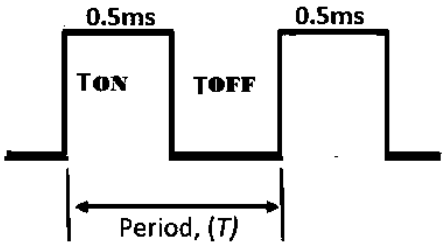



**Fig 16.2 : 50% Duty cycle Square wave**

Frequency = 2 KHZ
Time period T= 1/2 KHZ = 0.5 ms
Required time delay = TON = TOFF = T /2 = 0.5 ms / 2 = 0.25ms

## VII Practical Circuit diagram:

a) Sample Circuit diagram

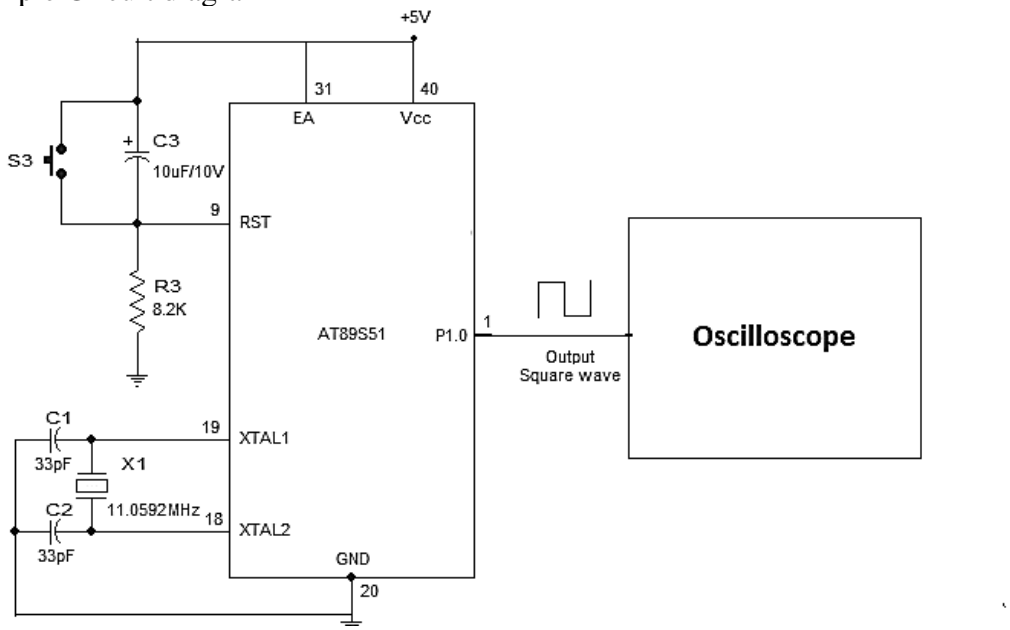



**Fig 16.3 : 8051 connection to CRO**

b) Simulation diagram

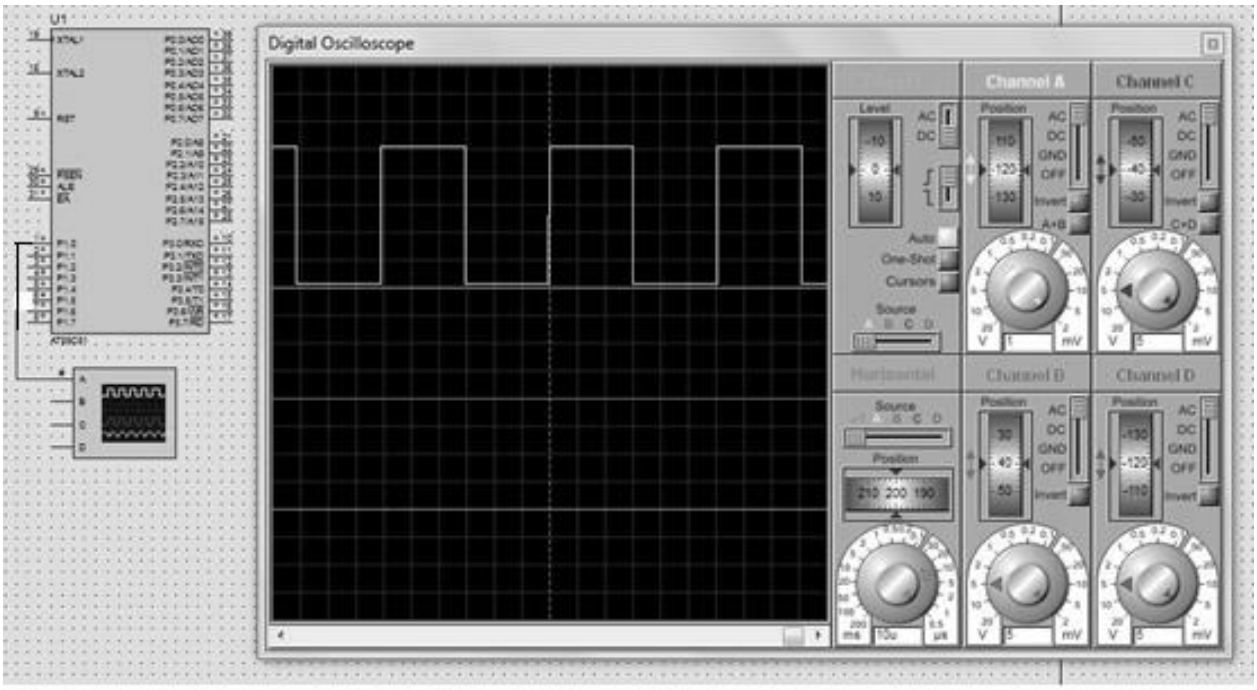



**Fig 16.4 Simulation diagram**

c) Actual circuit used in laboratory

**VIII Required Resources/apparatus/equipment with specifications**

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Microcontroller kit | Single board system with 8K RAM,ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross C-compiler,RS-232,USB, interfacing facility with built in power supply. | 1 No. |
| 2. | Desktop PC | Loaded with open source IDE, simulation and program downloading software. | 1 No. |
| 3. | CRO | Bandwidth AC 10Hz ~ 20MHz (-3dB). DC ~ 20MHz (-3dB), X10 Probe | 1 No. |

**IX Precautions to be followed**

1) Check rules / syntax of assembly language programming.

**X Procedure**

1. Write algorithm for given problem.
2. Draw flowchart for the same.
3. Develop assembly program using Integrated Development Environment (Keil IDE) or any other relevant software tool.
4. Debug program on IDE.
5. Execute program on IDE.

6. Create hex file for the program.
7. Download hex code in EPROM/Flash memory of microcontroller.
8. Connect CRO probe to port pin and observe waveform.
9. Measure ON time and OFF time on CRO and draw the same in observation Table.

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM:** To generate Pulse with pulse width of 1ms on P1.0 using Timer 0 Mode1. Assume XTAL = 11.0592MHz

**Step 1: Algorithm**

1. Load the TMOD register with value 01H, indicating Timer 0, Mode1
2. Clear Port pin P1.0
3. Call 1ms delay subroutine
4. Load registers TL0 and TH0 with initial count values for 1ms delay
5. Start the Timer 0.
6. Keep monitoring the timer flag (TF0) with the "JNB TF0, target" instruction to see if it is raised. Get out of the loop when TF0 becomes high.
7. Stop Timer0
8. Clear the TF0 flag for the next round.
9. Set Port pin P1.0
10. Go back to Step 3.

**Step 2: Flowchart**

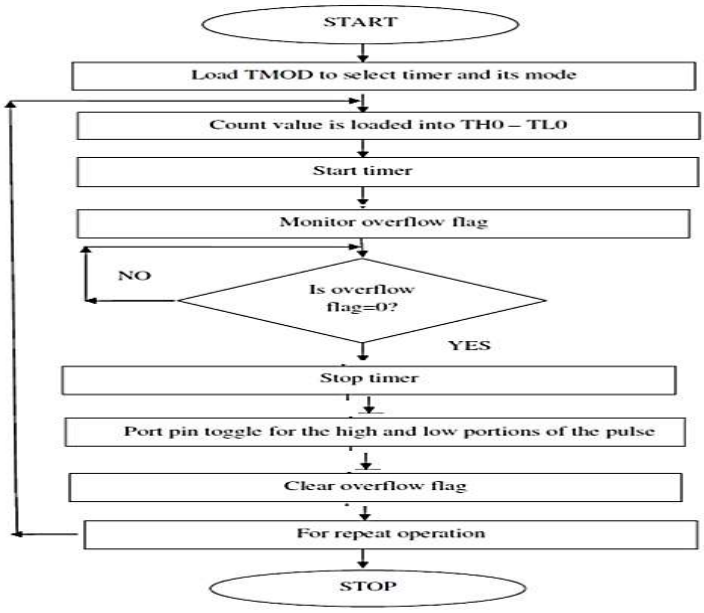



**Fig 16.3 Flowchart for Pulse generation**

**Step 3: Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | |
| C:0X0000 | 758901 | | MOV TMOD ,#01H | ;Timer 0, mode 1 |
| C:0X0003 | C290 | UP: | CLR P1.0 | ; Clear port pin P1.0 |
| C:0X0005 | 110D | | ACALL DELAY | ; call 1ms delay subroutine |
| C:0X0007 | D290 | | SETB P1.0 | ; Set port pin P1.0 |
| C:0X0009 | 110D | | ACALL DELAY | ; call 1ms delay subroutine |
| C:0X000B | 80F6 | | SJMP UP | ; Repeat |
| C:0X000D | 758A66 | DELAY: | MOV TL0,#66H | ;TL0=66H |
| C:0X0010 | 758CFC | | MOV TH0,#0FCH | ;TH0=FCH |
| C:0X0013 | D28C | | SETB TR0 | ;start Timer 0 |
| C:0X0015 | 308DFD | WAIT: | JNB TF0, WAIT | ;monitor Timer 0 overflow flag until it rolls over |
| C:0X0018 | C28C | | CLR TR0 | ;stop Timer 0 |
| C:0X001A | C28D | | CLR TF0 | ;clear Timer 0 overflow flag |
| C:0X001C | 22 | | RET | ;Return to main program |
| | | | END | |

**Problem statement for student:** Write a program to generate square wave of frequency 2KHZ on port pin P2.5 Using Timer 1, Mode 1. Assume XTAL = 11.0592MHz

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

| | |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
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**X I Resources used**

| Sr. No. | Name of Resource | Specifications | Quantity |
|---|---|---|---|
| | | | |
| | | | |

**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……

**XIII Observations for problem statement** (use blank sheet provided if space not sufficient)

Draw Square wave and show TON and TOFF time

**XIV Results (Output of the Program)**

……

……

**XV Interpretation of Results (Give meaning of the above obtained results)**

……..…

…….

**XVI Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

……..……..

……..……..

## XVII Practical related questions

***Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.***

1.Write ALP to generate square wave of pulse width 10 ms using Timer 1 Mode2.

2. Find value of TH and TL to generate square wave of frequency 1KHZ with 75% duty cycle Use Mode 1

**[Space for Answers]**

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## XVII References/Suggestions for further reading

1. https://www.nbcafe.in/ports-in-8051-microcontroller/#google_vignette
2. https://econtent.msbte.edu.in/econtent/econtent_home.php
3. https://www.circuitstoday.com/delay-using-8051-timer

## XVIII Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 17: LED matrix interfacing to 8051

## I Practical Significance

An LED matrix keyboard is a specialized input device that incorporates an LED matrix to enhance visual feedback and aesthetic appeal. LED matrix displays are used as stadium displays, decorative displays and as visual signals to human eye, to convey a message or meaning. LED matrix displays are interfaced with microcontroller I/O port to display characters and different patterns. This practical will help the students to develop skills to interface LED matrix display to microcontroller and display various pattern.

## II Industry/Employer expected outcome(s)

Maintain microcontroller-based systems.

## III Course Level Learning Outcome(s)

Interface memory and I/O peripherals to 8051 microcontroller.

## IV Laboratory Learning Outcome(s)

Interface 4x4 matrix with 8051 to display various patterns.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

In LED dot matrix display the LEDs are connected at the column and row intersections of the matrix. LEDs in the same row are connected together and LEDs in the column are connected together. Transistors are act as switches and used to control LEDs in the matrix

LED (Light Emitting Diode)

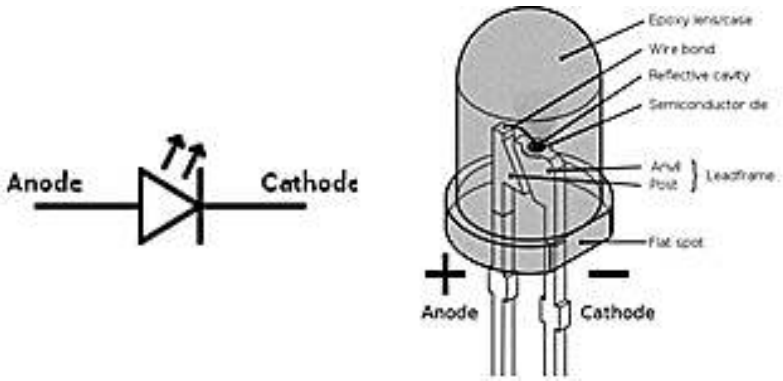


**Fig 17.1 LED Symbol and Construction**

**Specifications: LED**
1. Current: 20 mA
2. Voltage drop: 1.9 to 2.1 V
3. Power dissipation: 40 mW
4. Color: RED

**Operation:** Voltage +5V to anode with respect to cathode ground LED will turn ON.
Accessing individual LEDs :User can turn ON an individual LED by setting its row and column pins to the proper logic 1.
For example, referring to figure 17.2 LED matrix the switch in column 2 is closed which ties the anodes of all of the LEDs in that column to positive voltage and on the left the switch in row 1 is closed causing a ground level to be applied to the cathode of all of the LEDs in that row. The LED at the intersection of column 2 and row 1 is forward biased and turns on.

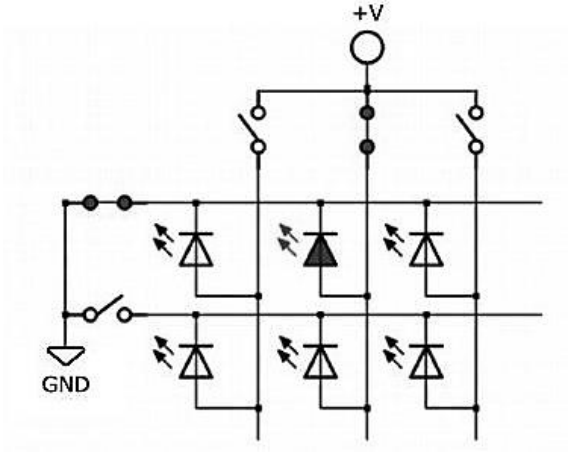


**Fig 17.2 Addressing individual LED: 2nd column and 1st row**

## VII Actual Circuit Diagram used in laboratory

### a) Sample Circuit Diagram

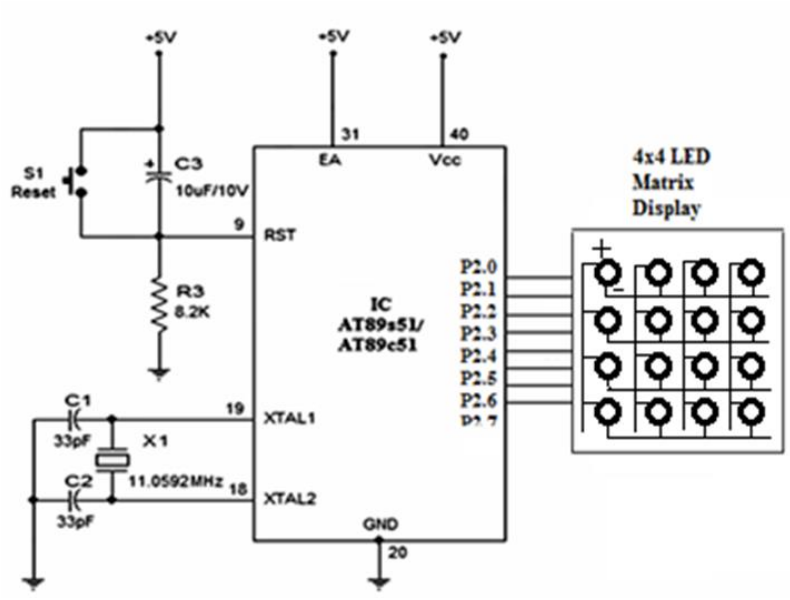


**Fig 17.3 Sample Circuit Diagram**

**b) Actual Circuit Diagram used:**

## VIII Resources Required

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1 | Microcontroller kit | Single board system with 8K RAM,ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler,RS-232,USB, interfacing facility with built in power supply. | 1 No. |
| 2 | Desktop PC | Loaded with open source IDE, simulation and program downloading software. | 1 No. |
| 3 | 4X4 LED matrix | Suitable to interface with 8051 trainer kit | 1 No |

## IX Precautions to be Followed

1. Check rules / syntax of assembly programming.

## X Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL and select AT89C51.
5. Type the program in text editor and save as filename.asm extension.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window.
11. Note the values of the result of various operations in the observation table.

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: Write program to display various patterns on 4x4 LED matrix.

**Step 1: Algorithm**

1. Make port P2 used to interface 4x4 LED matrix as an output port.
2. Send F1H value to the port to turn ON first column all LED.
3. Add delay.
4. Send 1FH value to the port to display first row all LED.
5. Add delay.
6. Send 11H value to the port to display first column first row LED.
7. Add delay.
8. Send 88H value to the port to display fourth column fourth row LED.
9. Add delay.
10. For repeat operation go to step 2.

**Step 2: Flowchart**

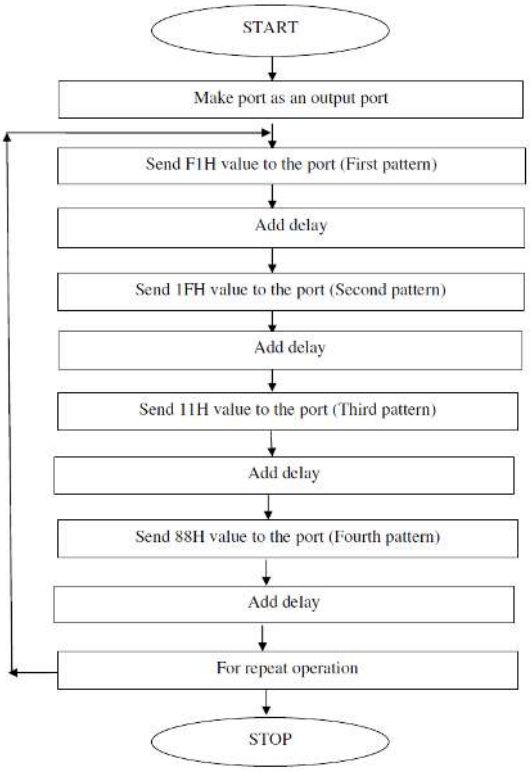


**Fig . 11.2 Flowchart for 4x4 LED matrix**

**Step 3: Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | |
| C:0x0000 | 75A000 | | MOV P2, #00H | Make port as output |
| C:0x0003 | 75A0F1 | | MOV P2, #0F1H | Send value to LED matrix |
| C:0x0006 | 1119 | RPT: | ACALL DELAY | Add delay |
| C:0x0008 | 75A01F | | MOV P2, #1FH | Send value to LED matrix |
| C:0x000B | 1119 | | ACALL DELAY | Add delay |
| C:0x000D | 75A011 | | MOV P2, #11H | Send value to LED matrix |
| C:0x0010 | 1119 | | ACALL DELAY | Add delay |
| C:0x0012 | 75A088 | | MOV P2, #88H | Send value to LED matrix |
| C:0x0015 | 1119 | | ACALL DELAY | Add delay |
| C:0x0017 | 80EA | | SJMP RPT | |
| C:0x0019 | 7A0A | | MOV R2, #10 | Delay subroutine |
| C:0x001B | 7B64 | DELAY: | MOV R3, #100 | |
| C:0x001D | 7CC8 | HERE2: | MOV R4, #200 | |
| C:0x001F | DCFE | HERE1: | DJNZ R4, HERE | |
| C:0x0021 | BDFA | HERE: | DJNZ R3, HERE1 | |
| C:0x0023 | DAF6 | | DJNZ R2, HERE2 | |
| C:0x0025 | 22 | | RET | |
| | | | END | |

**Problem statement for student**: Develop assembly program to turn ON and OFF all LEDs connected to port 2 with 30 msec delay.

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
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**XI Resources Used:**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | | | |

**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

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**XIII Observations for sample program** (use blank sheet provided if space not sufficient)

| HEX Value | LED status (ON/OFF) | |
|---|---|---|
| | Column | Row |
| F5H | | |
| 2FH | | |
| 17H | | |
| 90H | | |

**XIV Results** (Output of the Program)

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**XV Interpretation of Results (**Give meaning of the above obtained results)

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**XVI Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

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**XVII Practical Related Questions**

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

1. Give the difference between Common Anode and Common Cathode Display.
2. Specify the power requirement for 4x4 LED Matrix.
3. List the applications of 4 x 4 matrix keyboard.

**[Space for Answers]**

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## XVIII References / Suggestions for further reading

1. https://www.refreshnotes.com/2016/04/8051-program-exchange-block-of-data.html
2. https://www.tutorialspoint.com/program-branch-group-in-8051
3. https://www.codesexplorer.com/2016/12/8051-alp-to-move-data-from-internal-to-external.html

## XIX Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40% (10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 % (25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 18: Seven Segment Display interface for displaying decimal numbers

## I Practical Significance

Seven segment display is a output display device used to display information in the form of decimal numbers from 0 to 9 and in some cases, basic characters also. It is widely used in digital clocks, basic calculators, electronic meters, and other electronic devices that display numerical information. This practical will help the students to develop skills to interface 7-segment display to microcontroller and display decimal numbers.

## II Industry/Employer Expected Outcome(s)

Maintain microcontroller based systems.

## III Course Level Learning Outcome(s)

Interface the memory and I/O peripherals to 8051 microcontroller

## IV Laboratory Learning Outcome(s)

Interface 7-segment display to display the decimal number from 0 to 9.

## V Relevant Affective Domain related outcome(s)

1. Follow safe practices.
2. Maintain tools and equipment.
3. Follow ethical practices.

## V I Relevant Theoretical Background

Seven segment displays are of two types, i) Common Cathode Display ii) Common Anode Display

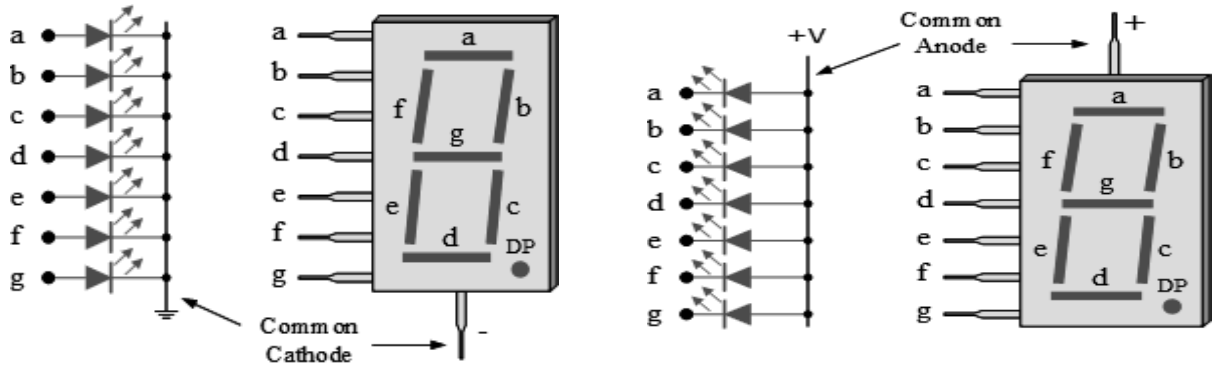


**Fig 18.1 Seven segment display types**

**Common Cathode:** In common cathode type, the cathodes of all LEDs are tied together to a single terminal which is usually labeled as '**com**' and the anode of all LEDs are left alone as individual pins labeled as a, b, c, d, e, f, g and h (or dot). To glow Common Cathode Segment LED, common terminal is grounded and Logic 1 is applied on segment pin.

**Common Anode:** In common anode type, the anode of all LEDs are tied together as a single terminal and cathodes are left alone as individual pins. Common Anode is tied to logic 1 and to glow segment Led logic 0 is applied on segment Pin

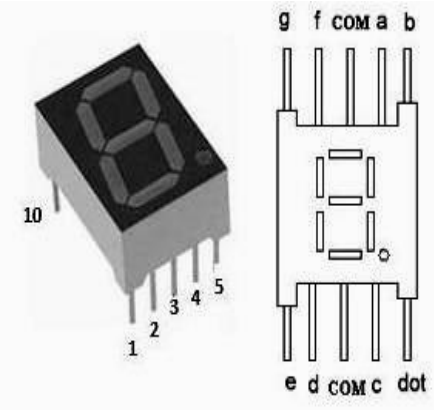


**Fig 18.2 Seven segment display and pin configuration**

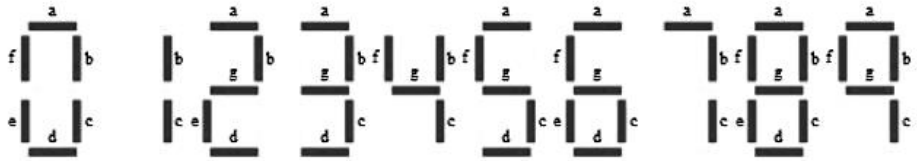

**Fig 18.3 Seven segment display number pattern**

**Driving Pattern for Digit:** Digit drive pattern of a seven segment LED display is simply the different logic combinations of its terminals **'a' to 'h**' in order to display different digits and characters. The common digit drive patterns (0 to 9) of a seven-segment display are shown in the table below.

**Common Cathode Pattern:**

**Table 18.1: Common Cathode Pattern Table**

| Digit | Dp | g | f | e | d | c | b | a | HEX CODE |
|---|---|---|---|---|---|---|---|---|---|
| Port | P2.7 | P2.6 | P2.5 | P2.4 | P2.3 | P2.2 | P2.1 | P2.0 | |
| 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 3FH |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 06H |
| 2 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 5BH |
| 3 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 4FH |
| 4 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 66H |
| 5 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 6DH |
| 6 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 7DH |
| 7 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 07H |
| 8 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7FH |
| 9 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 6FH |

**Common Anode Pattern:**

**Table 18.2: Common Anode Pattern Table**

| Digit | Dp | g | f | e | d | c | b | a | HEX CODE |
|---|---|---|---|---|---|---|---|---|---|
| Port | P2.7 | P2.6 | P2.5 | P2.4 | P2.3 | P2.2 | P2.1 | P2.0 | |
| 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | C0H |
| 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | F9H |
| 2 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | A4H |
| 3 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | B0H |
| 4 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 99H |
| 5 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 92H |
| 6 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 82H |
| 7 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | F8H |
| 8 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 80H |
| 9 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 90H |

***Note: in above patterns decimal point is considered OFF***

## VII Practical Circuit diagram:

a) Sample Circuit diagram

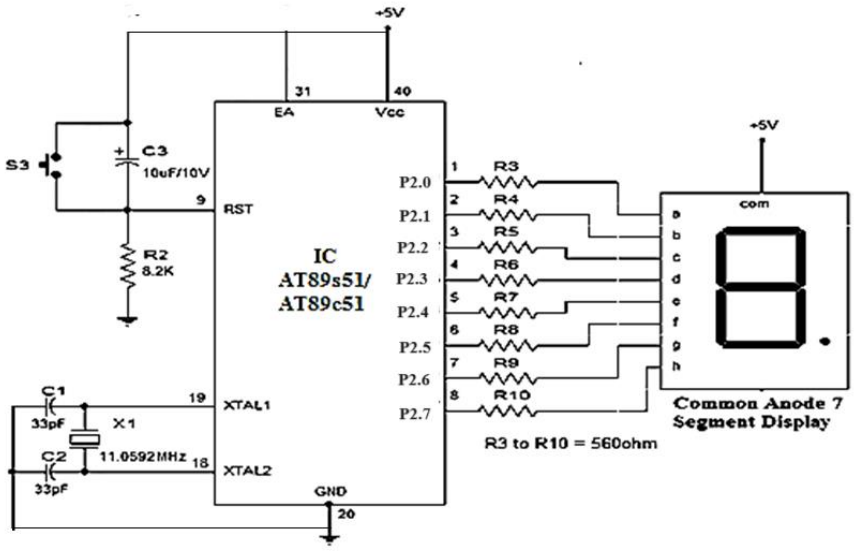


**Fig 18.4 8051 connection to Common Anode seven segment display**

b) Practical Setup

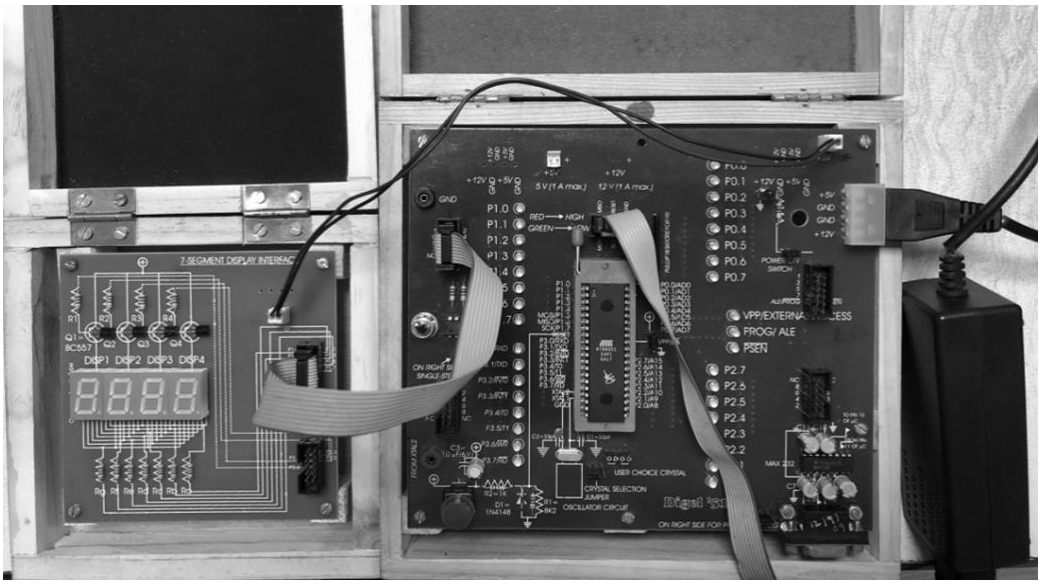

**Fig 18.5 Practical setup**

c) Simulation diagram

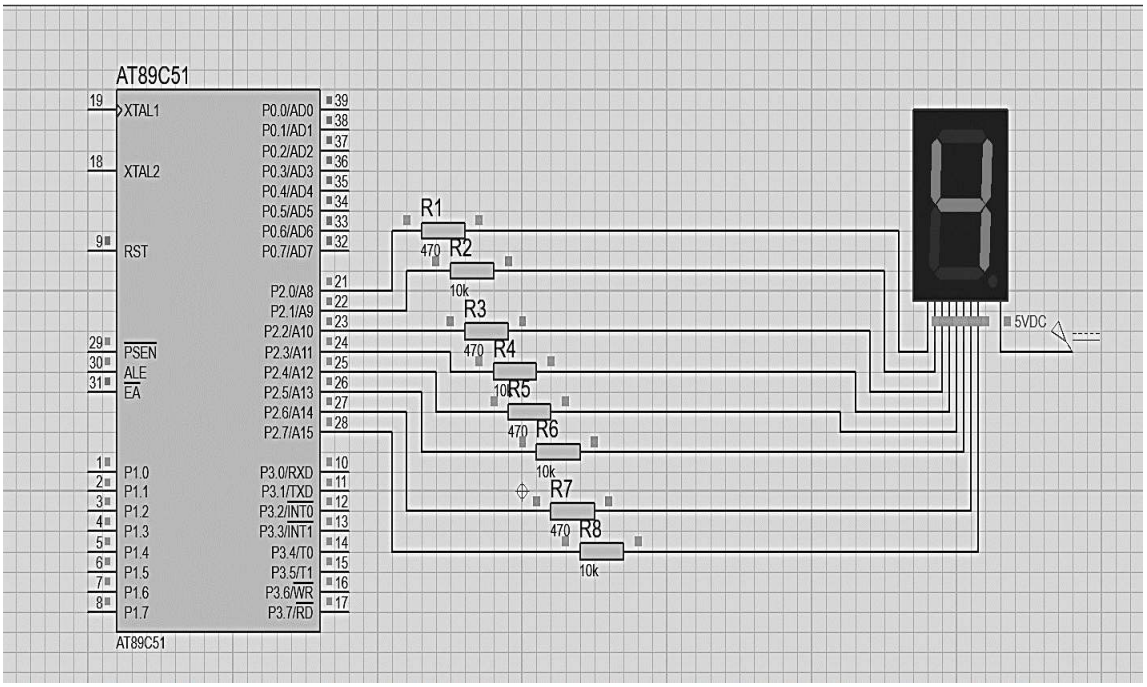


**Fig 18.6 Simulation diagram**

d) Actual circuit used in Laboratory

e) Actual Experimental set up used in laboratory

## VIII Required Resources/apparatus/equipment with specifications

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Microcontroller kit | Single board system with 8K RAM, ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross C-compiler, RS-232, USB, interfacing facility with built in power supply. | 1 No. |
| 2. | Desktop PC | Loaded with open-source IDE, simulation and program downloading software. | 1 No. |
| 3. | Seven Segment LED Display | 0. 56 in 1-digit Red, common anode/common cathode display. | 1 No. |

## IX Precautions to be followed

1) Always use current limiting resistor before interfacing 7-segment display to microcontroller.
2) For safe operation use seven segment displays at 25° temperature.
3) Check rules / syntax of assembly language programming.

## X Procedure

1. Write algorithm for given problem.
2. Draw flowchart.
3. Develop assembly program using Integrated Development Environment (Keil IDE) or any other relevant software tool.
4. Debug program on IDE.
5. Execute program on IDE.
6. Create hex file.
7. Download hex code in EPROM/Flash memory of microcontroller.
8. Interface Common Anode type 7 segment display to microcontroller as per circuit diagram shown in fig 18.4.
9. Observe and draw the display of numbers on 7-seven segment display.
10. Record the hex value in observation table.

### E-Waste Management

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: Write a program to display decimal no 0 to 9.

**Step 1: Algorithm**

1. Make the Port P2 as output port.
2. Set counter register R2 =10 for 0 to 9 digits.
3. Load DPTR with memory address where table is stored.
4. Clear Accumulator.
5. Read stored hex code of decimal digit from memory into Accumulator.
6. Send code to output port where 7-segment display is connected.
7. Increment memory pointer i.e., DPTR.
8. Decrement the counter register R2 and compare with 0 is counter =0? NO- go to step 4 to send next digit code.
9. For repeat operation go to step 2.
10. Stop

**Step 2: Flowchart**

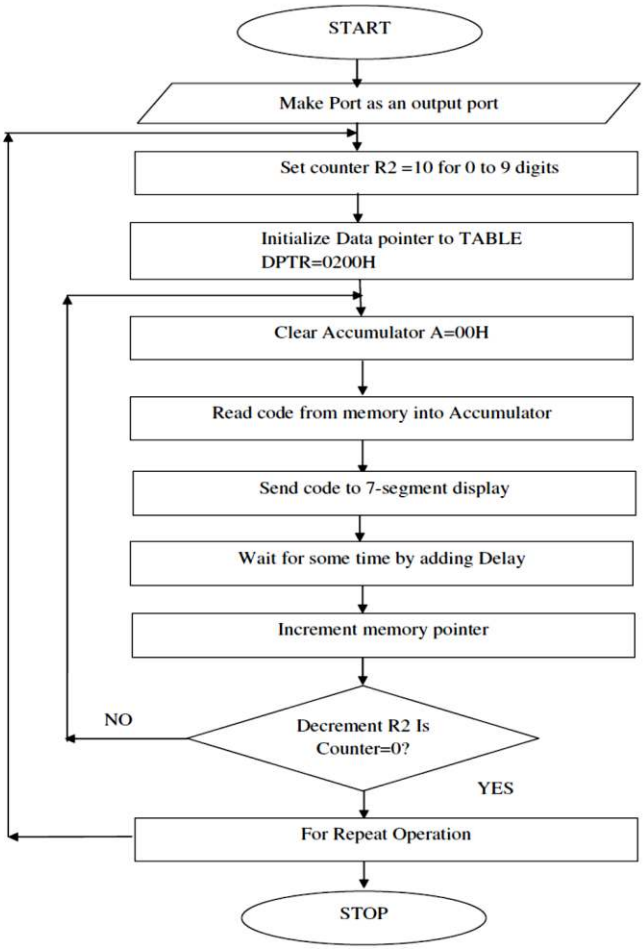


**Fig 18.7 Flowchart to display decimal no 0 to 9**

**Step 3: Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | |
| C:0x0000 | 75A000 | | MOV P2,#00H | ;Make Port2 as output port |
| C:0x0003 | 7A0A | REPEAT: | MOV R2,#10 | ;Set register as counter of 10 bytes |
| C:0x0005 | 900300 | | MOV DPTR,#TABLE | ;Load address of memory into Data pointer |
| C:0x0008 | E4 | UP: | CLR A | ;Clear accumulator |
| C:0x0009 | 93 | | MOVC A,@A+DPTR | ;Read hex code from memory into accumulator |
| C:0x000A | F5A0 | | MOV P2,A | ;Send hex code to port2 |
| C:0x000C | 1113 | | ACALL DELAY | |
| C:0x000E | A3 | | INC DPTR | ;Increment memory pointer to read next digit hex code |
| C:0x000F | DAF7 | | DJNZ R2,UP | ; Decrement counter & jump if not equal to zero to label UP. |
| C:0x0011 | 80F0 | | SJMP REPEAT | ;Repeat loop |
| C:0x0013 | 7B19 | DELAY: | MOV R3, #25 | ;Delay Subroutine |
| C:0x0015 | 7C64 | L3: | MOV R4,#100 | |
| C:0x0017 | 7D64 | L2: | MOV R5,#100 | |
| C:0x0019 | DDFE | L1: | DJNZ R5,L1 | |
| C:0x001B | DCFA | | DJNZ R4,L2 | |
| C:0x001D | DBF6 | | DJNZ R3,L3 | |
| C:0x001F | 22 | | RET | |
| | | | ORG 0300H | |
| | | TABLE: | DB 0C0H, 0F9H, 0A4H, 0B0H, 99H, 92H, 82H, 0F8H, 80H, 90H | ;Decimal 0 to 9 hex code stored at code memory starting at location 0200H onward |
| | | | END | |

**Problem statement for student**: Develop assembly program to display decimal numbers 9 to 0 on Common Anode/ Common Cathode 7-segment display

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
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**X I Resources used**

| Sr. No. | Name of Resource | Specifications | Quantity |
|---|---|---|---|
| | | | |
| | | | |

**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……

**XIII Observations for Problem statement** (use blank sheet provided if space not sufficient)

| Sr. NO. | Memory Location | Hex Value |
|---|---|---|
| 1 | C:0x0300 | |
| 2 | C:0x0301 | |
| 3 | C:0x0302 | |
| 4 | C:0x0303 | |
| 5 | C:0x0304 | |
| 6 | C:0x0305 | |
| 7 | C:0x0306 | |
| 8 | C:0x0307 | |
| 9 | C:0x0308 | |
| 10 | C:0x0309 | |

**XIV Results (Output of the Program)**

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**XV Interpretation of Results (Give meaning of the above obtained results)**

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**XVI Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

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**XVII Practical related questions**

***Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.***

1. Write the 7-segment hex code to display letter ‘E’ and ‘F’ on Common Anode display.
2. State number of pins a seven segment display IC have.
3. Write assembly language program to display numbers 4 and 5 alternately on common cathode seven segment display

**[Space for Answers]**

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## XVIII References/Suggestions for further reading

1. https://www.geeksforgeeks.org/seven-segment-displays/
2. https://www.electronics-tutorials.ws/blog/7-segment-display-tutorial.html
3. https://www.circuitstoday.com/interfacing-seven-segment-display-to-8051

## XIX Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 19: Relay interfacing to Microcontroller

## I Practical Significance

Electromagnetic or solid-state relays are used in electronic applications to switch or control high voltages or high currents. In Industrial applications low power devices microcontrollers drive relays are used to control electrical loads beyond their direct drive capability. Electromechanical protective relays are used to detect overload and other faults on electrical lines by opening and closing circuit breakers. This practical will help the students to develop skills to interface relay to microcontroller and turn it ON and OFF.

## II Industry/Employer expected outcome(s)

Maintain microcontroller-based systems.

## III Course Level Learning Outcome(s)

Interface memory and I/O peripherals to 8051 microcontroller.

## IV Laboratory Learning Outcome(s)

Interface relay with microcontroller and turn it ON and OFF.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

Turning a relay on and off is a fundamental function for controlling power to a device or circuit using a separate, usually lower voltage circuit. A relay is an electromechanical switch that uses an electromagnet to mechanically operate a switch.

**Turning a Relay On**:

1. To turn on the relay, a current must be applied to the coil. This can be done using a control signal from a microcontroller, a switch, or any digital output capable of driving the relay.
2. This input activates the coil, causing the contacts to close and allowing power to pass through to the connected device.

**Turning a Relay Off**:

1. To turn off the relay, the current flowing through the coil is interrupted. This can be achieved by cutting off the control signal or through a switch.
2. When the coil is de-energized, a spring or other mechanism forces the contacts back into the open position, cutting off power to the device.

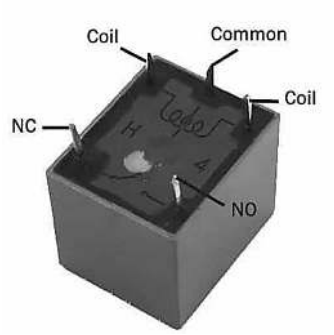


**Fig 19.1 Relay Terminals**

## VII Actual Circuit Diagram used in laboratory

### a) Sample Circuit Diagram

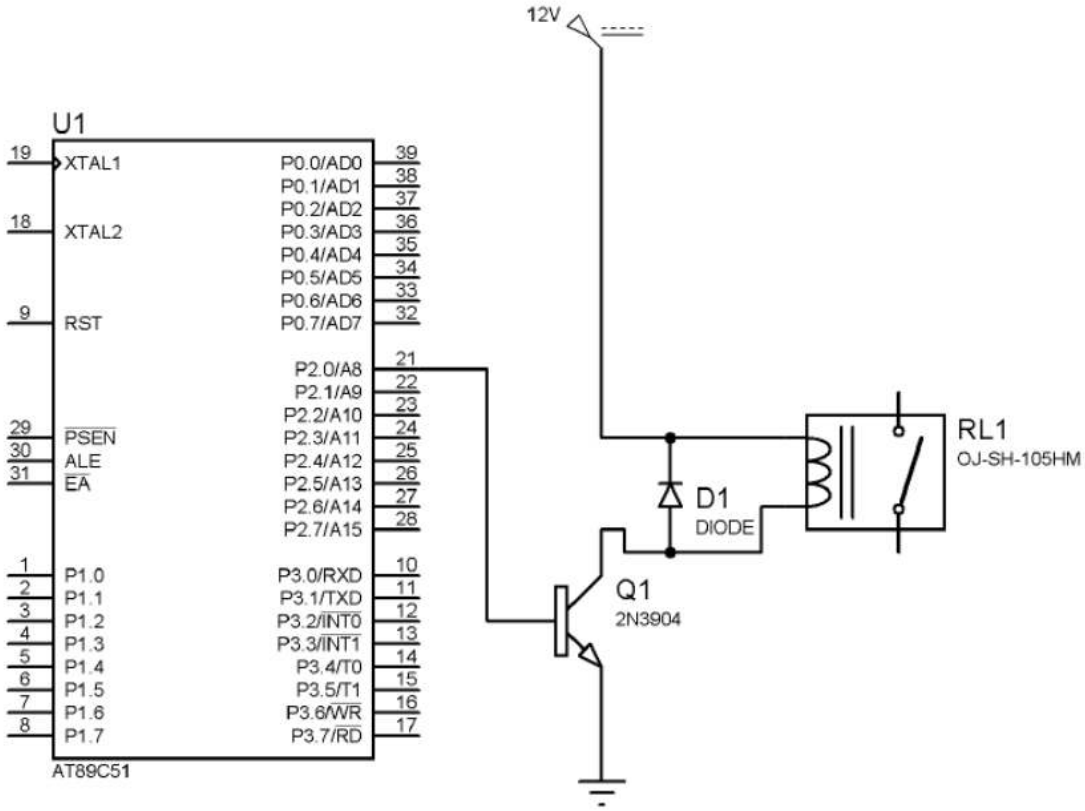


**Fig 19.2 Sample Circuit Diagram**

**b) Practical Setup:**

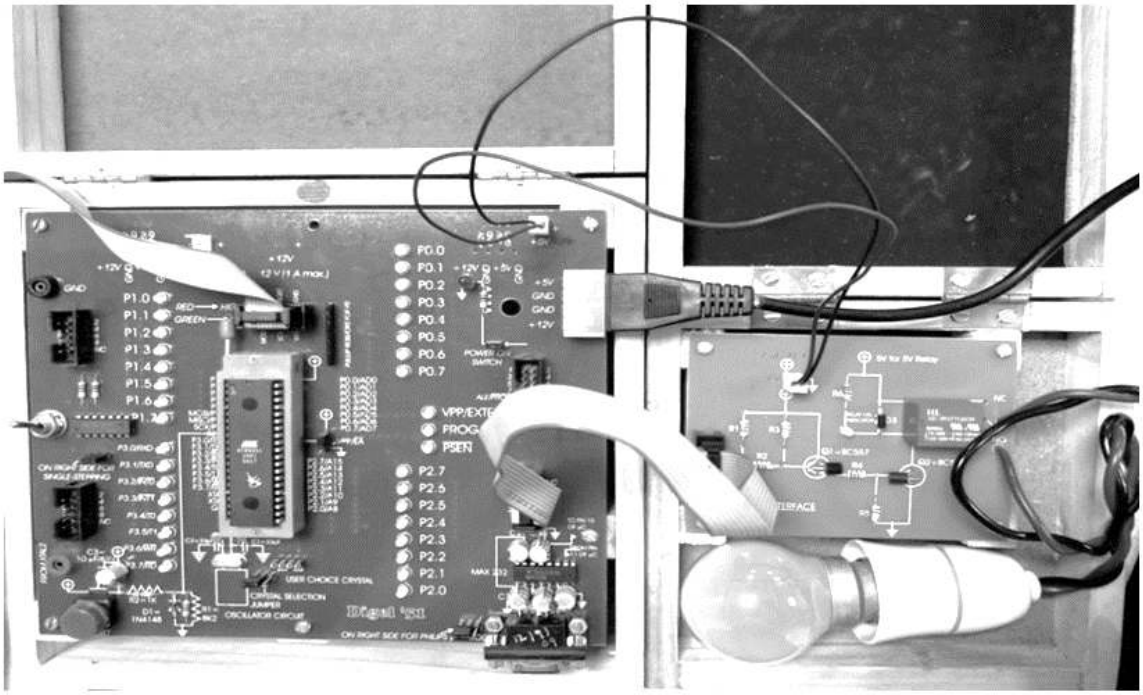


**Fig 19.3 Practical Set up Diagram**

**c) Actual Circuit Diagram used:**

## VIII Resources Required

| Sr. No | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Microcontroller kit | Single board systems with 8K RAM, ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler, RS-232, USB, interfacing facility with built in power supply. | 1 No. |
| 2. | Desktop PC | Loaded with open-source IDE, simulation & program downloading software | |
| 3 | Relay trainer board | Suitable to interface with 8051 trainer kit | 1 No. |

## IX Precautions to be Followed

1. Check rules / syntax of assembly programming.
2. Use always driver circuit before interfacing relay to the microcontroller.
3. Use fly back diode to avoid voltage spikes

## X Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL and select AT89C51.
5. Type the program in text editor and save as filename.asm extension.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window.
11. Note the values of the result of various operations in the observation table.

## E-Waste Management

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: Write program to display various patterns on 4x4 LED matrix.

**Step 1: Algorithm**

1. Make the Port pin P1.0 used to Interface relay as an output pin.
2. Turn on relay by setting port bit.
3. Add delay

4. Turn off relay by clearing bit
5. Add delay
6. For repeat operation go to step 2
7. Stop

**Step 2: Flowchart**

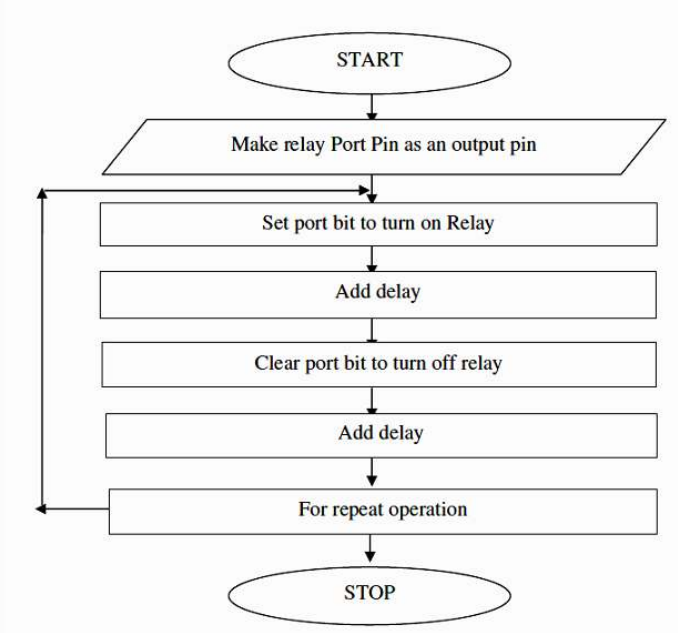


**Fig . 19.4 Flowchart for 4x4 LED matrix**

**Step 3: Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | |
| C:0x0000 | D290 | MAIN | SETB P2.0 | Set P2.0 high to turn ON the relay |
| C:0x0002 | 110A | | ACALL DELAY | Call Delay |
| C:0x0004 | C290 | | CLR P2.0 | Clear P2.0 low to turn OFF the relay |
| C:0x0006 | 110A | | ACALL DELAY | Call Delay |
| C:0x0008 | 80F6 | | SJMP MAIN | Infinite loop to toggle relay |
| | | | | |
| C:0x000A | 78FF | | MOV R0, #255 | |
| C:0x000C | 79FF | LOOP 1 | MOV R1, #255 | |
| C:0x000E | D9FE | LOOP 2 | DJNZ R1, LOOP 2 | Decrement and jump if not zero |
| C:0x0010 | D8FA | | DJNZ R0, LOOP 1 | |
| C:0x0012 | 22 | | RET | |
| | | | END | |

**Problem statement for student**: Develop assembly program to turn ON and OFF all Relay connected to port 2 with 30 msec delay.

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
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**XI Resources Used:**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
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**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

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**XIII Observations for sample program** (use blank sheet provided if space not sufficient)

| Sr. NO. | Step | Port Pin Status | Logic 1 (+5V) / Logic 0 (0V) | Relay Status ON/OFF |
|---|---|---|---|---|
| 1 | Step 1 | P2.0 | | |
| 2 | Step 2 | P2.0 | | |

**XIV Results** (Output of the Program)

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**XV Interpretation of Results (**Give meaning of the above obtained results)

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**XVI Conclusions and Recommendation (**Actions/decisions to be taken based on the interpretation of results).

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**XVII Practical Related Questions**

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

1. Give the effect of driver circuit not connected while interfacing relay with microcontroller.
2. Draw the Interfacing diagram of microcontroller with relay using ULN 2803A IC.
3. Write Steps for testing a relay.

**[Space for Answers]**

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## XVIII References / Suggestions for further reading

1. https://www.etechnog.com/2021/07/relay-wiring-diagram-and-function.html
2. https://bravelearn.com/turn-relay-on-or-off-using-8051-microcontroller-at89c51/
3. https://electrosome.com/interfacing-relay-8051-keil-c/

## XIX Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40% (10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 % (25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 20: LCD interfacing to 8051 to display characters and decimal numbers

## I Practical Significance

Display units are the most important output devices in embedded projects and electronics products. 16x2 LCD is one of the most used display unit. LCDs find application in consumer appliances such as CD players, DVD players, digital watches, computers, etc. These are commonly used in the screen industries. This practical will help the students to develop skills to interface LCD with microcontroller to display the given integer and character.

## II Industry/Employer Expected Outcome(s)

Maintain microcontroller based systems.

## III Course Level Learning Outcome(s)

Interface the memory and I/O peripherals to 8051 microcontroller

## IV Laboratory Learning Outcome(s)

Interface LCD with 8051 microcontroller to display the characters and decimal numbers.

## V Relevant Affective Domain related outcome(s)

1. Follow safe practices.
2. Maintain tools and equipment.
3. Follow ethical practices.

## V I Relevant Theoretical Background

A 16×2 LCD display is a very basic module and is very commonly used in various devices and circuits. A 16×2 LCD means it can display 16 characters per line and there are 2 such lines.

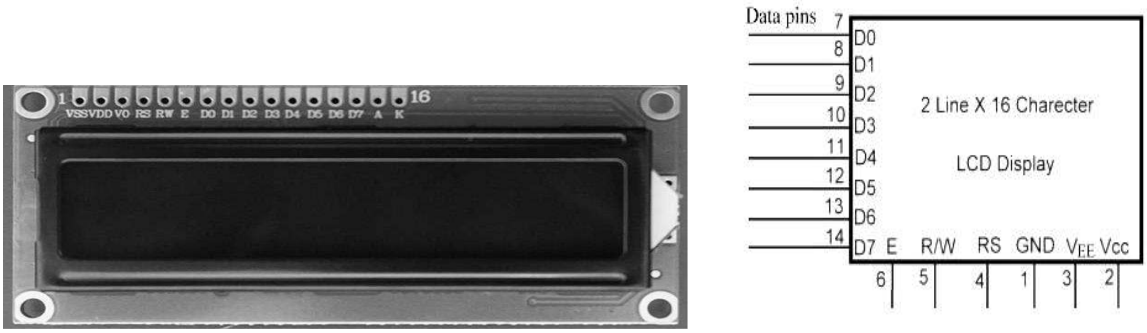


**Fig 20.1 16 X 2 LCD display**

### HD44780 16 X2 LCD Features

- The operating voltage is 4.7V-5.3V
- It includes two rows where each row can produce 16-characters.
- The utilization of current is 1mA with no backlight
- Every character can be built with a 5×8 pixel box
- The alphanumeric LCDs display alphabets & numbers
- It can work on two modes like 4-bit & 8-bit
- Available in Blue & Green Backlight

### LCD Pin functions:

**Table 20.1 LCD pin Functions**

| PIN NO | NAME | FUNCTION |
|---|---|---|
| 1 | GND | Ground pin. |
| 2 | VCC | Power supply pin of 5V. |
| 3 | VEE | Used for adjusting the contrast, commonly attached to the potentiometer. |
| 4 | RS | **RS is the register select pin**<br>If RS = 0, the instruction command code register is selected.<br>If RS = 1, the data register is selected |
| 5 | R/W | **R/W - read/write:**<br>R/W input allows the user to write information to the LCD or read information from it.<br>R/W = 1 when reading;<br>R/W =0 when writing. |
| 6 | E | **Enable pin** is used by the LCD to latch the information present on the data pins. A high-to-low pulse is needed to latch the data. This pulse must be a minimum of 450 ns wide. |
| 7 | D0 | D0-D7 Data pins for giving data (normal data like numbers characters or command data) which is meant to be displayed. |
| 8 | D1 | |
| 9 | D2 | |
| 10 | D3 | |
| 11 | D4 | |
| 12 | D5 | |
| 13 | D6 | |
| 14 | D7 | |
| 15 | LED+ | Back light Anode which should be connected to Vcc(5V) |
| 16 | LED- | Back light Cathode which should be connected to ground. |

**LCD Commands:**

**Table 20.2 LCD Commands**

| Sr.No. | Command Code (Hex) | Instruction |
|---|---|---|
| 1 | 0x30 | Function Set: 8-bit, 1 Line, 5x7 Dots |
| 2 | 0x38 | Function Set: 8-bit, 2 Line, 5x7 Dots |
| 3 | 0x20 | Function Set: 4-bit, 1 Line, 5x7 Dots |
| 4 | 0x28 | Function Set: 4-bit, 2 Line, 5x7 Dots |
| 5 | 0x06 | Entry Mode |
| 6 | 0x08 | Display off Cursor off |
| 7 | 0x0E | Display on Cursor on |
| 8 | 0x0C | Display on Cursor off |
| 9 | 0x0F | Display on Cursor blinking |
| 10 | 0x18 | Shift entire display left |
| 11 | 0x1C | Shift entire display right |
| 12 | 0x10 | Move cursor left by one character |
| 13 | 0x14 | Move cursor right by one character |
| 14 | 0x01 | Clear Display (also clear DDRAM content) |
| 15 | 0x80 + address* | Set DDRAM address or cursor position on display |
| 16 | 0x40 + address** | Set CGRAM address or set pointer to CGRAM location |

Note: For more details of the commands refer Data sheet of LCD.

## VII Practical Circuit diagram:

a) Sample Circuit diagram

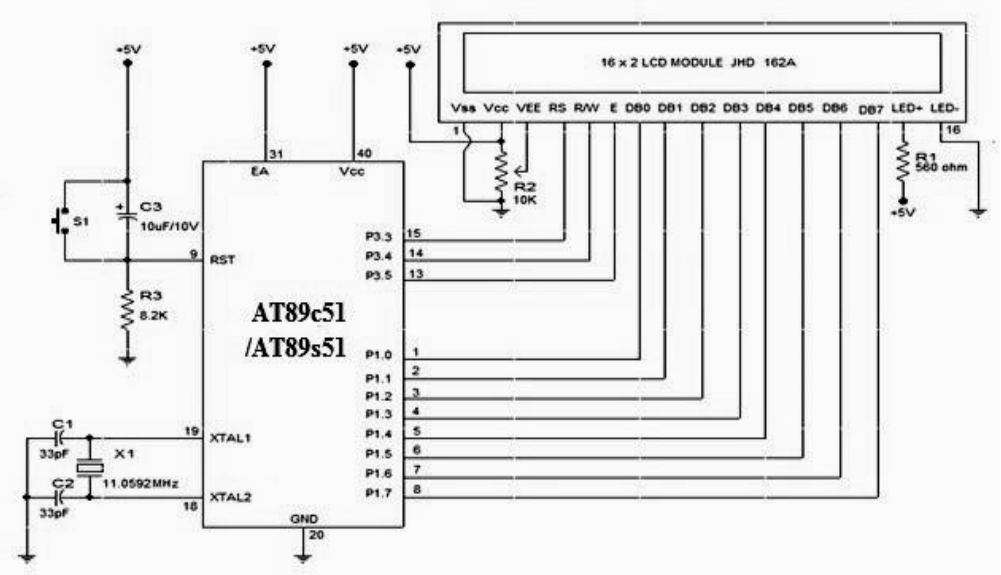


**Fig 20.2 8051 connection to 16 X 2 LCD display**

b) Practical Setup

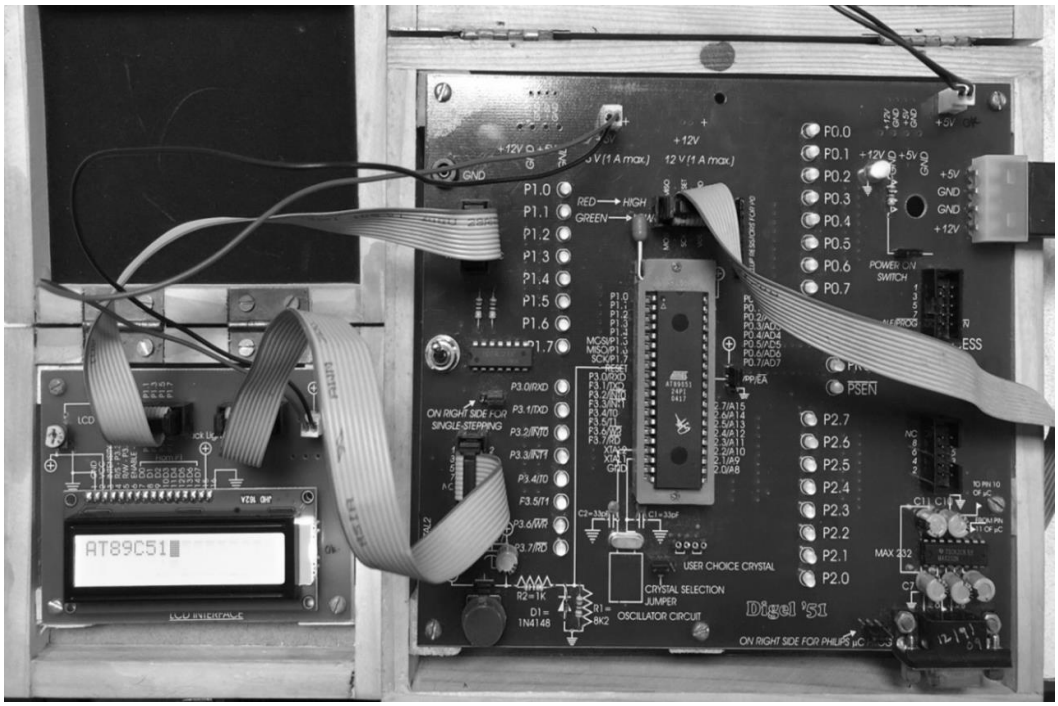


**Fig 20.3 Practical setup**

c) Simulation diagram

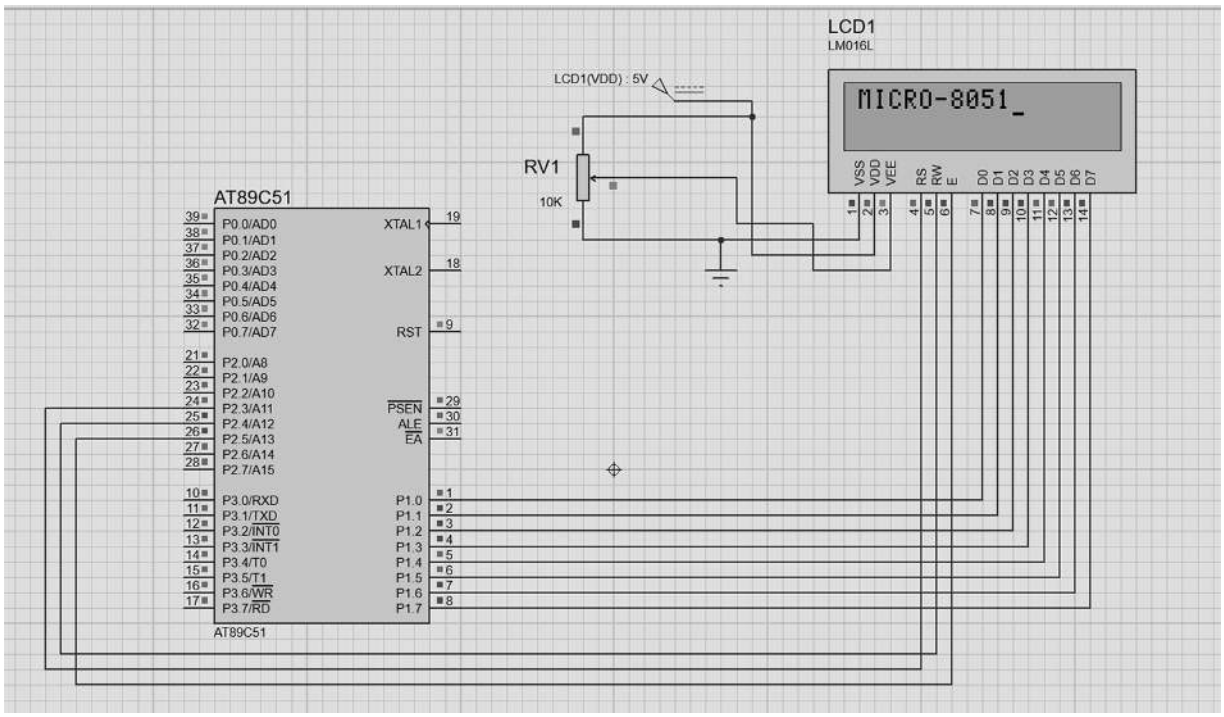


**Fig 20.4 Simulation diagram**

d) Actual circuit used in Laboratory

e) Actual Experimental set up used in laboratory

## VIII Required Resources/apparatus/equipment with specifications

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Microcontroller kit | Single board system with 8K RAM,ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross C-compiler,RS-232,USB, interfacing facility with built in power supply. | 1 No. |
| 2. | Desktop PC | Loaded with open source IDE, simulation and program downloading software. | 1 No. |
| 3. | LCD Trainer board | Suitable to interface with 8051 trainer kit | 1 No. |

## IX Precautions to be followed

1) Ensure proper connection before turning ON power supply to the kit.
2) Don't apply pressure to the display surface.
2) Check rules / syntax of assembly language programming.

## X Procedure

1. Write algorithm for given problem.
2. Draw flowchart for the same.
3. Develop assembly program using Integrated Development Environment (IDE) or any other relevant software tool.
4. Debug program on IDE.
5. Execute program on IDE.
6. Create hex file for the above program.
7. Interface LCD display to microcontroller as per circuit diagram shown in Fig 20.2
8. Download hex code in EPROM/Flash memory of microcontroller
9. Observe output on LCD display

### E-Waste Management

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM** : Write a program to display “MICRO-8051” on LCD.

**Step 1-Algorithm**

1. Define control signals RS, RW and EN for LCD
2. Make LCD connected port as an output port.
3. Initialize LCD by sending commands.
4. Load DPTR with program memory address.
5. Set register as counter R2 =10(decimal) for to display “MICRO-8051"
6. Clear Accumulator
7. Read ASCII from code memory into Accumulator.
8. Send code to output port where LCD is connected.
9. Increment memory pointer.
10. Decrement R2 counter. Is count ≠ 0 , then go to step 6.
11. Stop

**Step 2: Flowchart**

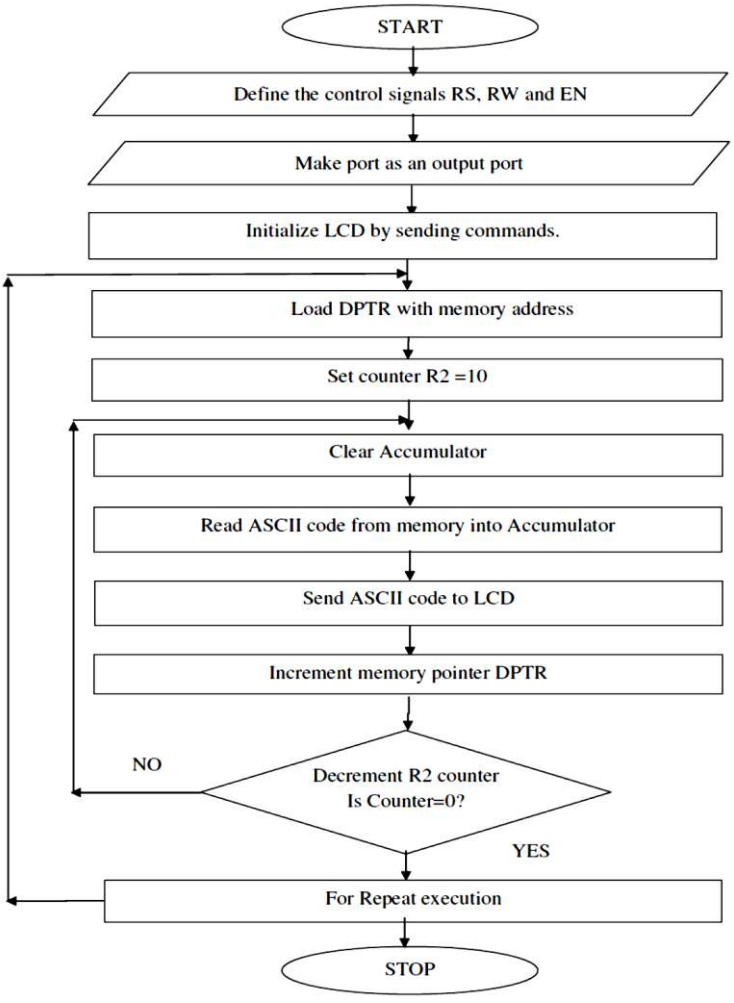


**Fig 20.5 Flowchart to display alphabets and decimal numbers on LCD**

**Step 3: Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | RS EQU P2.3 | ;Replace a bit address by a symbol |
| | | | RW EQU P2.4 | |
| | | | EN EQU P2.5 | |
| | | | ORG 0000H | |
| C:0x0000 | 759000 | | MOV P1, #00H | ;Set P1 as o/p port where LCD is connected |
| C:0x0003 | 120015 | | LCALL LCD_INIT | ;Call LCD initialize subroutine |
| C:0x0006 | 900100 | | MOV DPTR, #MSG | ; Load program memory address into DPTR |
| C:0x0009 | 7A0A | | MOV R2, #10 | ;Set counter of 10 |
| C:0x000B | E4 | UP: | CLR A | |
| C:0x000C | 93 | | MOVC A,@A+DPTR | ;Read data from memory into A register |
| C:0x000D | 120037 | | LCALL DATAWRT | |
| C:0x0010 | A3 | | INC DPTR | ;Increment pointer to next location |
| C:0x0011 | DAF8 | | DJNZ R2, UP | ;Repeat loop for 10 times |
| C:0x0013 | 80FE | HERE: | SJMP HERE | ; stop |
| C:0x0015 | 7438 | LCD_INIT: | MOV A, #38H | ; 2 lines and 5×7 matrix (8-bit mode) |
| C:0x0017 | 112A | | ACALL CMD | |
| C:0x0019 | 740E | | MOV A, #0EH | ; Display on, cursor on |
| C:0x001B | 112A | | ACALL CMD | |
| C:0x001D | 7406 | | MOV A, #06H | ; Increment cursor (shift cursor to right) |
| C:0x001F | 112A | | ACALL CMD | |
| C:0x0021 | 7401 | | MOV A, #01H | ; Clear display screen |
| C:0x0023 | 112A | | ACALL CMD | |
| C:0x0025 | 7480 | | MOV A, #80H | ; Force cursor to beginning to 1st line |
| C:0x0027 | 112A | | ACALL CMD | |
| C:0x0029 | 22 | | RET | |
| C:0x002A | F590 | CMD: | MOV P1,A | ;Send command to lcd |
| C:0x002C | C2A3 | | CLR RS | ;Select command register |
| C:0x002E | C2 A4 | | CLR RW | ;Select write operation |
| C:0x0030 | D2A5 | | SETB EN | |
| C:0x0032 | C2A5 | | CLR EN | ;Latch command to lcd |
| C:0x0034 | 1144 | | ACALL DELAY | ;Wait for sometime |
| C:0x0036 | 22 | | RET | |

| | | | | |
|---|---|---|---|---|
| C:0x0037 | F590 | DATAWRT: | MOV P1,A | ;Send data to lcd |
| C:0x0039 | D2 A3 | | SETB RS | ;Select data register |
| C:0x003B | C2 A4 | | CLR RW | ;Select write operation |
| C:0x003D | D2A5 | | SETB EN | |
| C:0x003F | C2A5 | | CLR EN | ;Latch data to lcd |
| C:0x0041 | 1144 | | ACALL DELAY | ;Wait for sometime |
| C:0x0043 | 22 | | RET | |
| C:0x0044 | 7B32 | DELAY: | MOV R3,#50 | ;Delay subroutine |
| C:0x0046 | 7CFF | L2: | MOV R4,#255 | |
| C:0x0048 | DCFE | L1: | DJNZ R4,L1 | |
| C:0x004A | DBFA | | DJNZ R3,L2 | |
| C:0x004C | 22 | | RET | |
| | | | ORG 0100H | |
| | | MSG: | DB “MICRO-8051" | ;Define data byte to code memory |
| | | | END | |

**Problem statement for student**: Develop assembly language program to display “MSBTE” on second line of LCD

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

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**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
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| Memory Address | Hex Code | Label | Mnemonics | Comments |
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## X I Resources used

| Sr. No. | Name of Resource | Specifications | Quantity |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……
9. ……

**XIII Observations for Problem statement** (use blank sheet provided if space not sufficient)

| Sr. No. | LCD Memory Location | Observed Character |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| 6 | | |
| 7 | | |

**XIV Results (Output of the Program)**

……

……

**XV Interpretation of Results (Give meaning of the above obtained results)**

……..…

…….

**XVI Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

……..……..

……..……..

## XVII Practical related questions

***Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.***

1. State necessity of busy flag checking in LCD.
2. Give DDRAM address for 1st and 2nd line of 16x2 LCD display
3. Write appropriate command to shift cursor position to left

**[Space for Answers]**

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## XVIII References/Suggestions for further reading


1. https://circuitdigest.com/article/16x2-lcd-display-module-pinout-datasheet
2. https://www.dnatechindia.com/Interfacing-LCD-to-8051.html
3. https://circuitdigest.com/microcontroller-projects/lcd-interfacing-with-8051-microcontroller-89s52
4. https://www.elprocus.com/lcd-interfacing-with-8051-microcontroller/


## XIX Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 21: Keyboard interfacing to 8051

## I Practical Significance

Keyboards allow users to input data directly into an embedded system. This interaction is essential for devices that require user configuration, command entry, or data input, enhancing usability and functionality. A keyboard interface with an 8051 microcontroller can be customized to handle various types of keyboards and input methods. This flexibility allows developers to design interfaces that best suit their specific application needs. This practical will help the students to develop skills to interface given keyboard to the microcontroller and display key pressed.

## II Industry/Employer expected outcome(s)

Maintain microcontroller-based systems.

## III Course Level Learning Outcome(s)

Interface memory and I/O peripherals to 8051 microcontroller.

## IV Laboratory Learning Outcome(s)

Interface the given keyboard with 8051 and display the key pressed.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

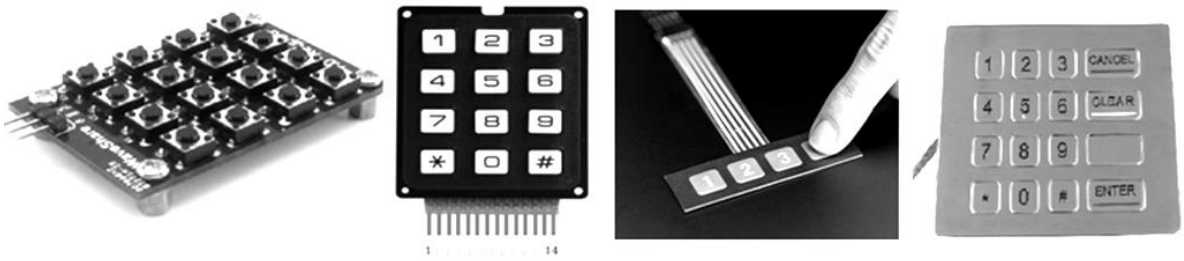


**Fig 21.1 Types of Keyboards**

4 x 4 matrix keypad connected to a single port of microcontroller. The keypad columns and rows are connected to the port pins. The keypad can be decoded to find out which key was pressed. When a key is pressed on the keypad, a row and column make a contact; otherwise, there is no connection

**Specifications: Keypad**

1. Maximum voltage across each key: 24V
2. Maximum Current through each key: 30mA
3. Maximum operating temperature: 0°C to + 50°C
4. Easy interface
5. Long life

**Table 21.1 4x4 Keypad: - Rows (R1, R2, R3, R4) Columns (C1, C2, C3, C4)**
**(Refer Fig.15.2)**

| | |
|---|---|
| Step1:- Make R1- 0 Checks C1, C2, C3,C4<br>If C1=0 – '0' is pressed<br>If C2=0 – '1' is pressed<br>If C3=0 – '2' is pressed<br>If C3=0 – '3' is pressed | Step3:- Make R3- 0 Checks C1, C2, C3,C4<br>If C1=0 – '8' is pressed<br>If C2=0 – '9' is pressed<br>If C3=0 – 'A' is pressed<br>If C3=0 – 'B' is pressed |
| Step2:- Make R2- 0 Checks C1, C2, C3,C4<br>If C1=0 – '4' is pressed<br>If C2=0 – '5' is pressed<br>If C3=0 – '6' is pressed<br>If C3=0 – '7' is pressed | Step4:- Make R4- 0 Checks C1, C2, C3,C4<br>If C1=0 – 'C' is pressed<br>If C2=0 – 'D' is pressed<br>If C3=0 – 'E' is pressed<br>If C3=0 – 'F' is pressed |

## VII Actual Circuit Diagram used in laboratory

### a) Sample Circuit Diagram

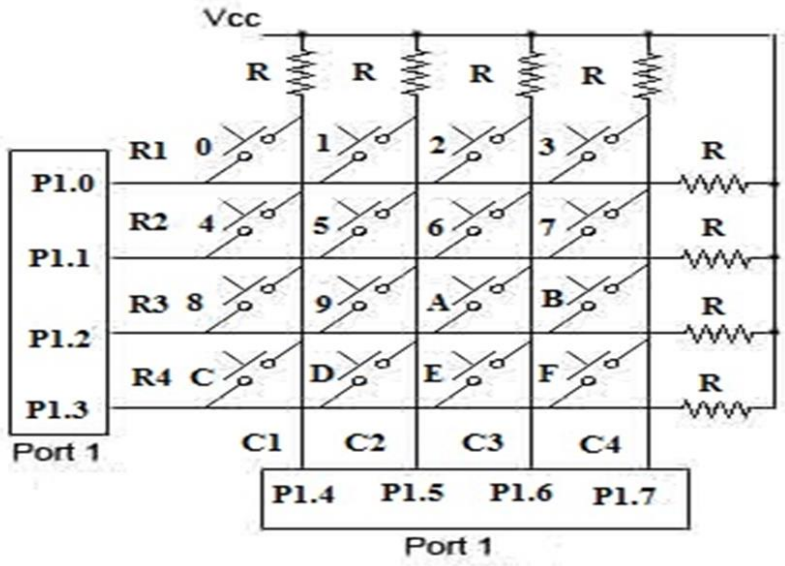


**Fig 21.2 Sample Circuit Diagram**

**b) Practical Setup:**

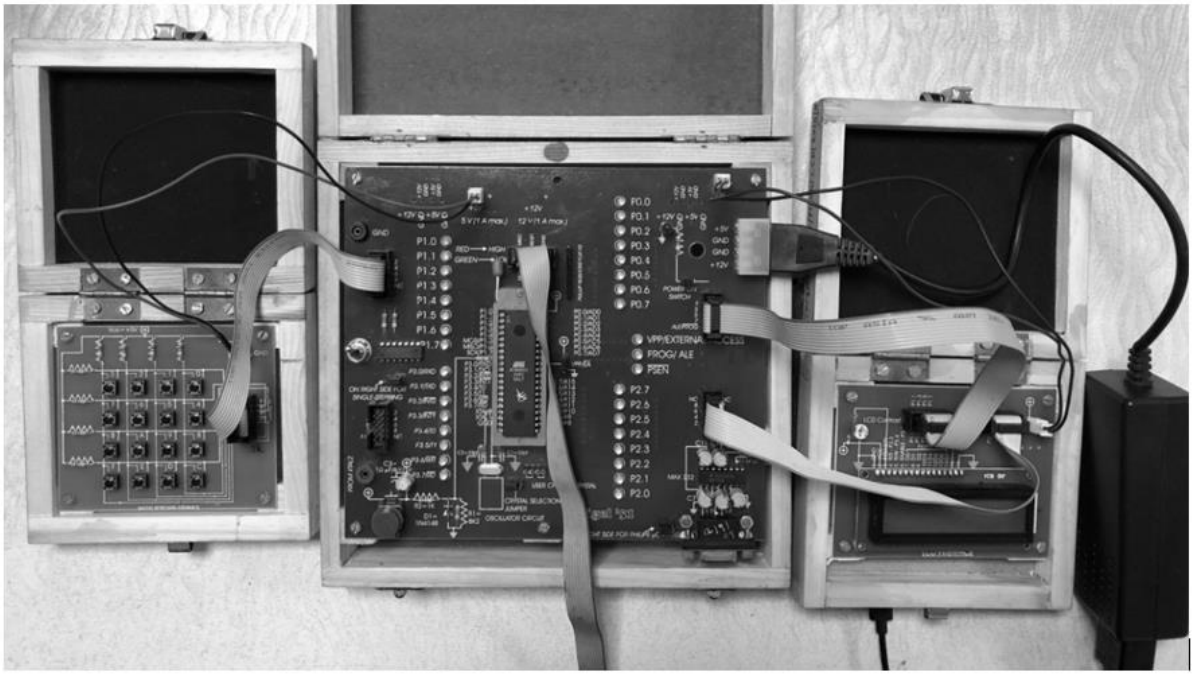

**Fig 21.3 Practical Set up Diagram**

**c) Simulation Diagram:**

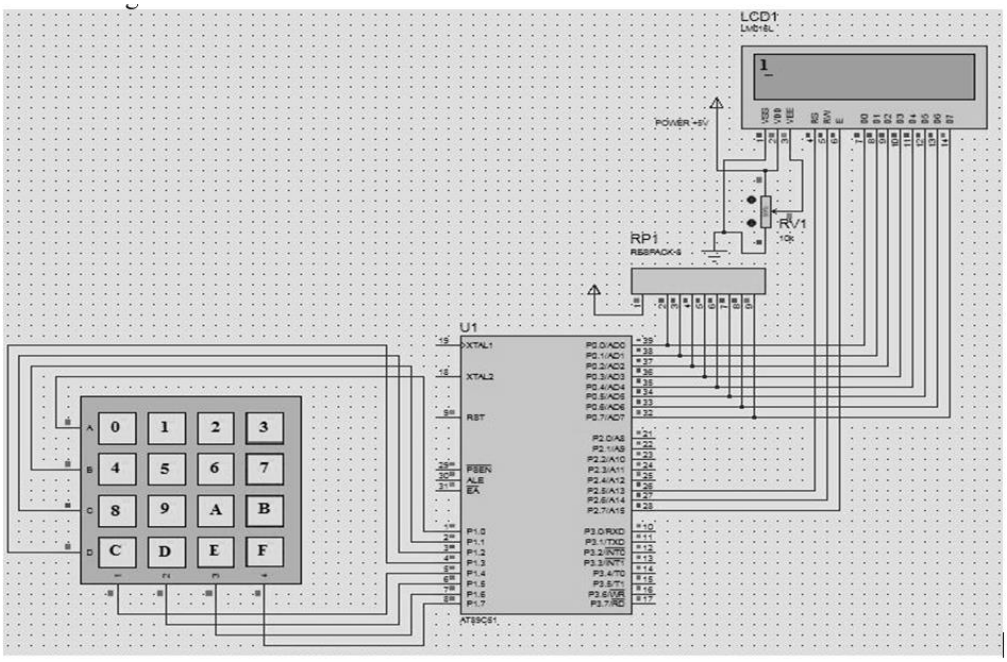


**Fig 21.4: Simulation Diagram**

**d) Actual Circuit Diagram used:**

## VIII Resources Required

| Sr. No | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Microcontroller kit | Single board systems with 8K RAM, ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler,RS-232,USB, interfacing facility with built in power supply. | 1 No. |
| 2. | Desktop PC | Loaded with open source IDE, simulation and program downloading software | 1 No. |
| 3 | Keyboard 4x4 trainer board | Suitable to interface with 8051 trainer kit | 1No. |

## IX Precautions to be Followed

1. Check rules / syntax of assembly programming.

## X Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL and select AT89C51.
5. Type the program in text editor and save as filename.asm extension.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window.
11. Note the values of the result of various operations in the observation table.

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: Write a program to display key pressed on LCD.

**Step1- Algorithm**

1. Define LCD control pins RS, RW, EN.
2. Make LCD Port P0 as an output port.
3. Make the keypad Port P1 pins as an input port.
4. Initialize LCD by sending commands.
5. Make R1 low& read columns C1, C2, C3 and C4
   If C1=0 display '0', If C2=0 display '1', If C3=0 display '2', If C4=0 display '3'
6. Make R2 low& read columns C1, C2, C3 and C4.
   If C1=0 display '4', If C2=0 display '5', If C3=0 display '6', If C4=0 display '7'.
7. Make R3 low& read columns C1, C2, C3 and C4.
   If C1=0 display '8', If C2=0 display '9', If C3=0 display 'A', If C4=0 display 'B'
8. Make R4 low& read columns C1, C2, C3 and C4.
   If C1=0 display 'C', If C2=0 display 'D', If C3=0 display 'E', If C4=0 display 'F'
1. Go to step 5 to scan keypad.
2. Stop

**Step 2-Flow Chart**

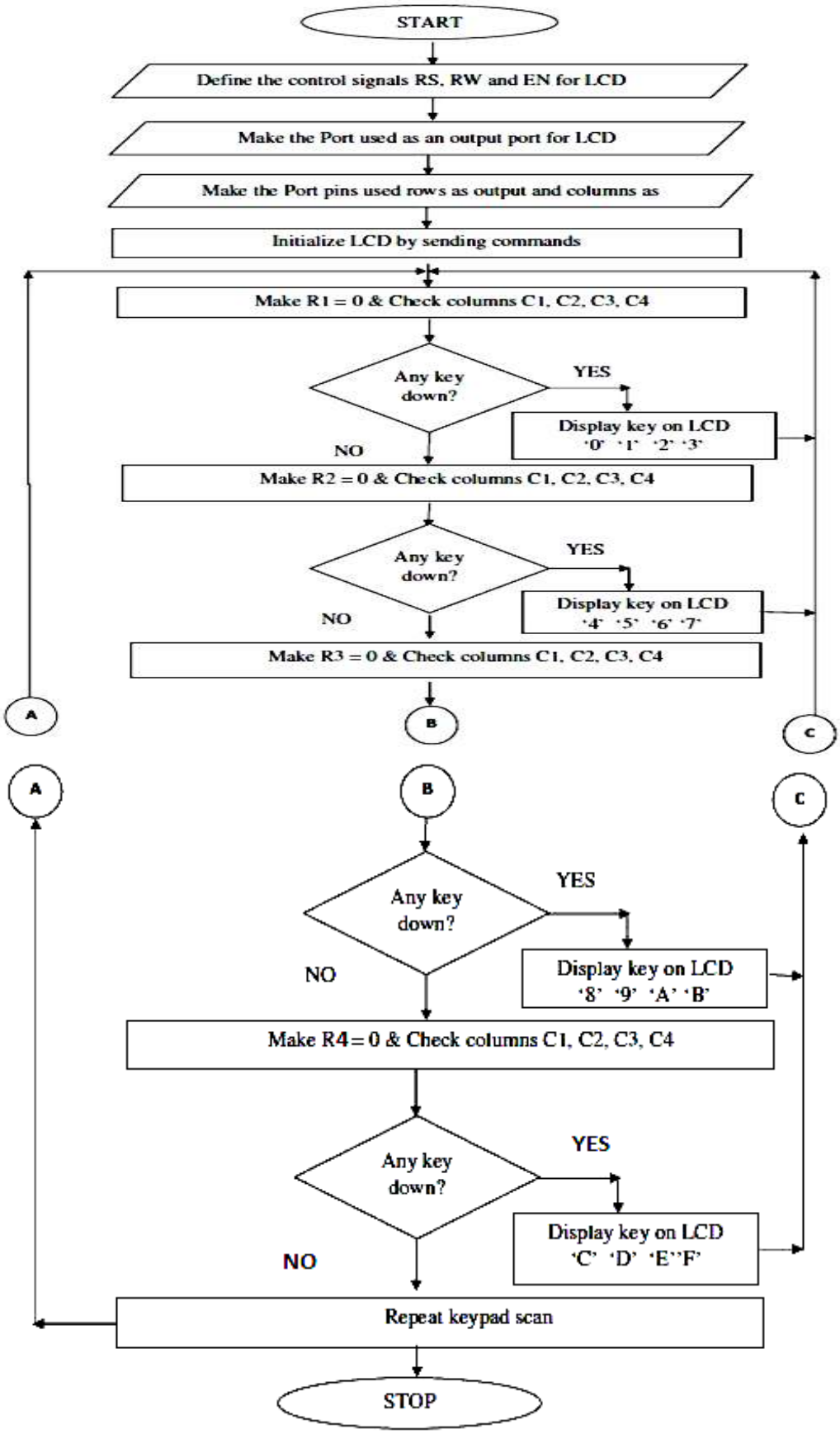


**Fig 21.5 Flowchart to display the key pressed on LCD**

**Step 3-Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ROW1 BIT P1.0 | ;keypad row pins |
| | | | ROW2 BIT P1.1 | |
| | | | ROW3 BIT P1.2 | |
| | | | ROW4 BIT P1.3 | |
| | | | COL1 BIT P1.4 | ;keypad column pins |
| | | | COL2 BIT P1.5 | |
| | | | COL3 BIT P1.6 | |
| | | | COL4 BIT P1.7 | |
| | | | RS BIT P2.5 | ;LCD control pins |
| | | | RW BIT P2.6 | |
| | | | EN BIT P2.7 | |
| | | | ORG 0000H | |
| C:0x0000 | 758000 | | MOV P0,#00H | ;make LCD port as output |
| C:0x0003 | 11AB | | ACALL LCDINIT | |
| C:0x0005 | 7590FF | KEYSCAN: | MOV P1,#0FFH | ;step 1 make port as input |
| C:0x0008 | C290 | | CLR ROW1 | ;make row1=0 |
| C:0x000A | 30943E | | JNB COL1,K0 | ;check col1 |
| C:0x000D | 309441 | | JNB COL2,K1 | ;check col2 |
| C:0x0010 | 309444 | | JNB COL3,K2 | ;check col3 |
| C:0x0013 | 309447 | | JNB COL4,K3 | ;check col4 |
| C:0x0016 | 7590FF | | MOV P1,#0FFH | ;step 2 |
| C:0x0019 | C291 | | CLR ROW2 | ;make row2=0 |
| C:0x001B | 309445 | | JNB COL1,K4 | |
| C:0x001E | 309548 | | JNB COL2,K5 | |
| C:0x0021 | 30964B | | JNB COL3,K6 | |
| C:0x0024 | 30974E | | JNB COL4,K7 | |
| C:0x0027 | 7590FF | | MOV P1,#0FFH | ;step 3 |
| C:0x002A | C292 | | CLR ROW3 | ;make row3=0 |
| C:0x002C | 30954C | | JNB COL1,K8 | |
| C:0x002F | 30954F | | JNB COL2,K9 | |
| C:0x0032 | 309652 | | JNB COL3,KA | |
| C:0x0035 | 309755 | | JNB COL4,KB | |
| C:0x0038 | 7590FF | | MOV P1,#0FFH | ;step 4 |
| C:0x003B | C293 | | CLR ROW4 | ;make row4=0 |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x003D | 309453 | | JNB COL1,KC | |
| C:0x0040 | 309556 | | JNB COL2,KD | |
| C:0x0043 | 309659 | | JNB COL3,KE | |
| C:0x0046 | 30975C | | JNB COL4,KF | |
| C:0x0049 | 80BA | | SJMP KEYSCAN | ;repeat scanning |
| C:0x004B | 7430 | K0: | MOV A,#"0" | ;key 0 detected |
| C:0x004D | 11CD | | ACALL DISPLAY | |
| C:0x004F | 0105 | | AJMP KEYSCAN | |
| C:0x0051 | 7431 | K1: | MOV A,#"1" | ;key 1 detected |
| C:0x0053 | 11CD | | ACALL DISPLAY | |
| C:0x0055 | 0105 | | AJMP KEYSCAN | |
| C:0x0057 | 7432 | K2: | MOV A,#"2" | ;key 2 detected |
| C:0x0059 | 11CD | | ACALL DISPLAY | |
| C:0x005B | 0105 | | AJMP KEYSCAN | |
| C:0x005D | 7433 | K3: | MOV A,#"3" | ;key 3 detected |
| C:0x005F | 11CD | | ACALL DISPLAY | |
| C:0x0061 | 0105 | | AJMP KEYSCAN | |
| C:0x0063 | 7434 | K4: | MOV A,#"4" | ;key 4 detected |
| C:0x0065 | 11CD | | ACALL DISPLAY | |
| C:0x0067 | 0105 | | AJMP KEYSCAN | |
| C:0x0069 | 7435 | K5: | MOV A,#"5" | ;key 5 detected |
| C:0x006B | 11CD | | ACALL DISPLAY | |
| C:0x006D | 0105 | | AJMP KEYSCAN | |
| C:0x006F | 7436 | K6: | MOV A,#"6" | ;key 6 detected |
| C:0x0071 | 11CD | | ACALL DISPLAY | |
| C:0x0073 | 0105 | | AJMP KEYSCAN | |
| C:0x0075 | 7437 | K7: | MOV A,#"7" | ;key 7 detected |
| C:0x0077 | 11CD | | ACALL DISPLAY | |
| C:0x0079 | 0105 | | AJMP KEYSCAN | |
| C:0x007B | 7438 | K8: | MOV A,#"8" | ;key 8 detected |
| C:0x007D | 11CD | | ACALL DISPLAY | |
| C:0x007F | 0105 | | AJMP KEYSCAN | |
| C:0x0081 | 7439 | K9: | MOV A,#"9" | ;key 9 detected |
| C:0x0083 | 11CD | | ACALL DISPLAY | |
| C:0x0085 | 0105 | | AJMP KEYSCAN | |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x0087 | 7441 | KA: | MOV A,#"A" | ;key A detected |
| C:0x0089 | 11CD | | ACALL DISPLAY | |
| C:0x008B | 0105 | | AJMP KEYSCAN | |
| C:0x008D | 7442 | KB: | MOV A,#"B" | ;key B detected |
| C:0x008F | 11CD | | ACALL DISPLAY | |
| C:0x0091 | 0105 | | AJMP KEYSCAN | |
| C:0x0093 | 7443 | KC: | MOV A,#"C" | ;key C detected |
| C:0x0095 | 11CD | | ACALL DISPLAY | |
| C:0x0097 | 0105 | | AJMP KEYSCAN | |
| C:0x0099 | 7444 | KD: | MOV A,#"D" | ;key D detected |
| C:0x009B | 11CD | | ACALL DISPLAY | |
| C:0x009D | 0105 | | AJMP KEYSCAN | |
| C:0x009F | 7445 | KE: | MOV A,#"E" | ;key E detected |
| C:0x00A1 | 11CD | | ACALL DISPLAY | |
| C:0x00A3 | 0105 | | AJMP KEYSCAN | |
| C:0x00A5 | 7446 | KF: | MOV A,#"F" | ;key F detected |
| C:0x00A7 | 11CD | | ACALL DISPLAY | |
| C:0x00A9 | 0105 | | AJMP KEYSCAN | |
| C:0x00AB | 7438 | LCDINIT: | MOV A,#38H | ;init LCD 2 lines, 5x7 matrix |
| C:0x00AD | 11C0 | | ACALL COMMAND | |
| C:0x00AF | 740E | | MOV A,#0EH | ;LCD on cursor on |
| C:0x00B1 | 11C0 | | ACALL COMMAND | |
| C:0x00B3 | 7406 | | MOV A,#06H | ;clear LCD command |
| C:0x00B5 | 11C0 | | ACALL COMMAND | |
| C:0x00B7 | 7401 | CLEAR: | MOV A,#01H | ;shift cursor right |
| C:0x00B9 | 11C0 | | ACALL COMMAND | |
| C:0x00BB | 7480 | | MOV A,#80H | ;Force cursor to beginning of 1st line |
| C:0x00BD | 11C0 | | ACALL COMMAND | |
| C:0x00BF | 22 | | RET | |
| C:0x00C0 | F580 | COMMAND: | MOV P0,A | ;issue command code |
| C:0x00C2 | C2A5 | | CLR RS | |
| C:0x00C4 | C2A6 | | CLR RW | |
| C:0x00C6 | D2A7 | | SETB EN | |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x00C8 | 11DE | | ACALL DELAY | |
| C:0x00CA | C2A7 | | CLR EN | |
| C:0x00CC | 22 | | RET | |
| C:0x00CD | F580 | DISPLAY: | MOV P0,A | ;issue data |
| C:0x00CF | D2A5 | | SETB RS | |
| C:0x00D1 | C2A6 | | CLR RW | |
| C:0x00C3 | D2A7 | | SETB EN | |
| C:0x00D5 | 11DE | | ACALL DELAY | |
| C:0x00D7 | C2A7 | | CLR EN | |
| C:0x00D9 | 11DE | | ACALL DELAY | ;add delay |
| C:0x00DB | 11B7 | | ACALL CLEAR | ;LCD clear |
| C:0x00DD | 22 | | RET | |
| C:0x00DE | 7B32 | | MOV R3,#50 | |
| C:0x00E0 | 7CFF | | MOV R4,#255 | |
| C:0x00E2 | DCFE | DELAY: | DJNZ R4,LOOP1 | |
| C:0x00E4 | DBFA | LOOP2: | DJNZ R3,LOOP2 | |
| C:0x00E6 | 22 | LOOP1: | RET | |
| | | | END | |

**XI Resources Used:**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |

**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

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**XIII Observations for sample program** (use blank sheet provided if space not sufficient)

| Sr. No. | Key Pressed | Output on LCD |
|---|---|---|
| 1 | 4 | |
| 2 | 5 | |
| 3 | A | |
| 4 | C | |
| 5 | F | |

**XIV Results** (Output of the Program)

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**XV Interpretation of Results** (Give meaning of the above obtained results)

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**XVI Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

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## XVII Practical Related Questions

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

1. If the switch 3 is pressed which column & row show logic 0 at respective port pin?.
2. Explain debounce effect.
3. Write down following requirement of port pins and number of switches.

| Matrix Keypad | No of switches | Rows Port Pins | Columns Port Pins |
|---|---|---|---|
| 1x4 Matrix Keypad | | | |
| 3x4 Matrix Keypad | | | |
| 4x4 Matrix Keypad | | | |
| 8x8 Matrix Keypad | | | |

**[Space for Answers]**

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**XVIII References / Suggestions for further reading**

1. https://gmostofabd.github.io/8051-Keypad/
2. https://www.circuitstoday.com/interfacing-hex-keypad-to-8051
3. https://www.brainkart.com/article/Interfacing-and-Program-for-Keyboard-to-8051-Microcontroller_7838/

**XIX Assessment Scheme**

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40% (10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 % (25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 22: ADC interfacing to 8051

## I Practical Significance

ADC (Analog to digital converter) forms a very essential part in many embedded projects. In industry and automated instruments, the signals sensed and processed by humans are analog signals. Analog-to-digital conversion is the means by which analog signals are converted into digital data that can be processed by computers for various purposes. This practical will help the students to develop skills to interface given ADC to the microcontroller and verify the input and output.

## II Industry/Employer expected outcome(s)

Maintain microcontroller-based systems.

## III Course Level Learning Outcome(s)

Interface memory and I/O peripherals to 8051 microcontroller.

## IV Laboratory Learning Outcome(s)

Interface ADC with 8051 microcontroller and verify input and output.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

An analog to digital converter or ADC, converts an analog signal to a digital signal. An analog signal has a continuously changing amplitude with respect to time. A digital signal, is a stream of 0s and 1s. An ADC maps analog signals to their binary equivalents. To do this, ADCs use various methods like:

1. Flash conversion,
2. Slope integration, or
3. Successive approximation.

**Types of ADC:**

1. **Serial ADC:** Serial ADC's consisting of just one output pin that delivers the output code one bit at a time.
2. **Parallel ADC:** Parallel ADC's consisting of several output pins that deliver all the bits of the output code at the same time.

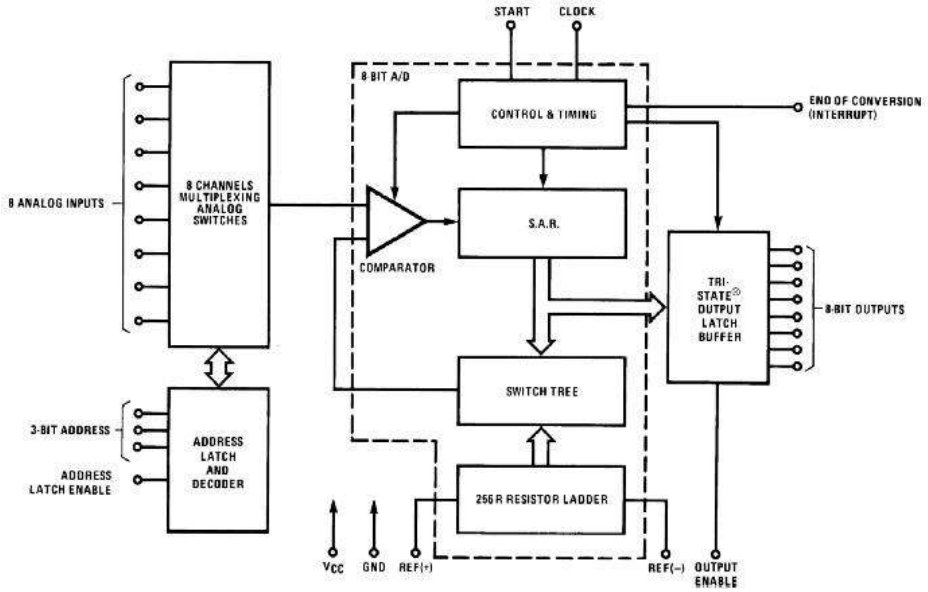


**Fig 22.1: ADC Block Diagram**

**ADC0808 Analog signal selection:**

**Table 22.1 ADC Channel Selection**

| Select Lines | | | Analog Channel Selected |
|---|---|---|---|
| C | B | A | |
| 0 | 0 | 0 | IN0 |
| 0 | 0 | 1 | IN1 |
| 0 | 1 | 0 | IN2 |
| 0 | 1 | 1 | IN3 |
| 1 | 0 | 0 | IN4 |
| 1 | 0 | 1 | IN5 |
| 1 | 1 | 0 | IN6 |
| 1 | 1 | 1 | IN7 |

## Specifications ADC0808 Chip

a. ADC0808 IC - analog to digital
b. Resolution -8 Bits
c. Input Channels- 8
d. Single Supply- 5VDC
e. Low Power- 15mW
f. Conversion Time -100µs
g. Output's meets TTL voltage level.
h. The clock frequency range of ADC is 10 KHz to 1280 KHz.
i. Typically 680 kHz used.
j. Low power consumption

## VII Actual Circuit Diagram used in laboratory

### a) Sample Circuit Diagram

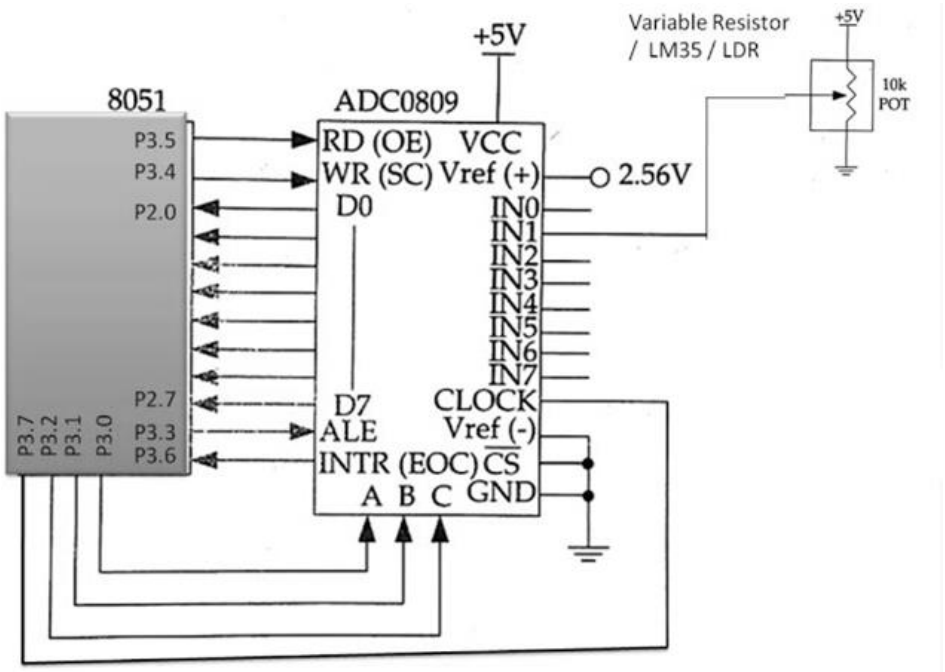


**Fig 22.2 ADC interfacing to 8051**

### b) Practical Setup:

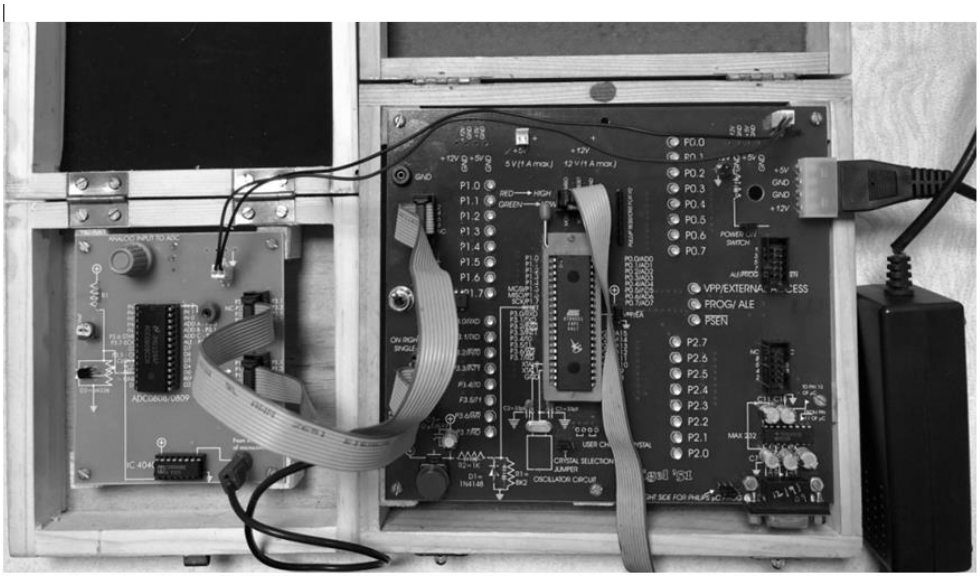

**Fig 22.3 Practical Set up Diagram**

### c) Simulation Diagram:

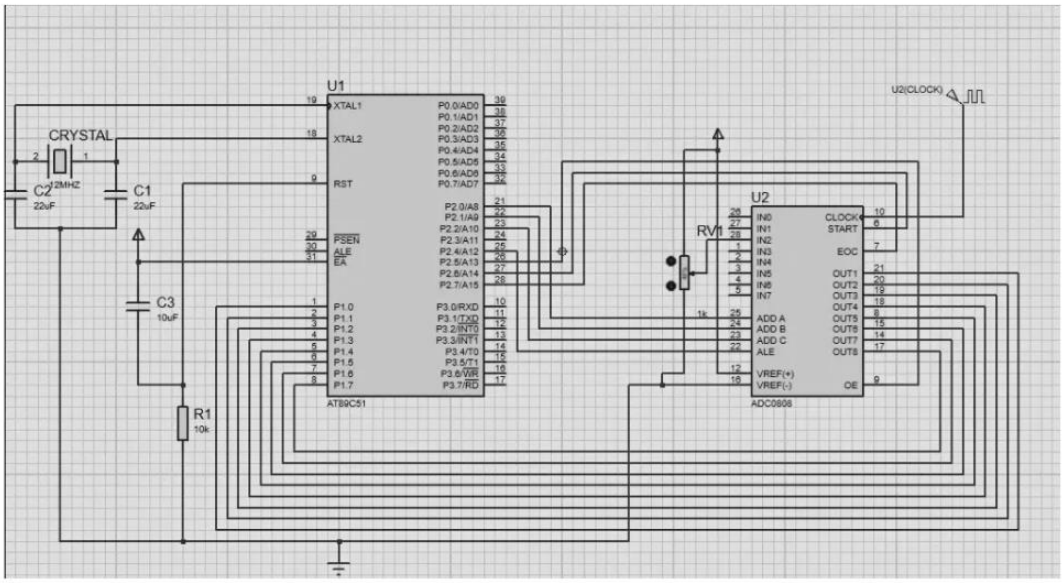


**Fig 22.4: Simulation Diagram**

### d) Actual Circuit Diagram used:

## VIII Resources Required

| Sr. No | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Microcontroller kit | Single board systems with 8K RAM, ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler, RS-232, USB, interfacing facility with built in power supply. | 1 No. |
| 2. | Desktop PC | Loaded with open-source IDE, simulation and program downloading software | 1 No. |
| 3 | ADC (0808) trainer board | Suitable to interface 8051 board. | 1 No. |

## IX Precautions to be Followed

1. Check rules / syntax of assembly programming.
2. Refer datasheet for to provide clock frequency to ADC 0808 chip.
3. Care must be taken while taking observations during power up.
4. Use current limiting resistors for LED's.

## X Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL and select AT89C51.
5. Type the program in text editor and save as filename.asm extension.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window.
11. Note the values of the result of various operations in the observation table.

## E-Waste Management

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: Write a program to read the data from ADC and display on LEDs.

**Step1- Algorithm**

1. Select an analog channel by providing bits to A, B, and C addresses according to the analog signal selection table.

2. Activate the ALE (address latch enable) pin.
3. Activate SC (start conversion) to initiate conversion.
4. Monitor EOC (end of conversion) to see whether conversion is finished. H-to L output indicates that the data is converted and is ready to be picked up. If we do not use EOC, we can read the converted digital data after a brief time delay. The delay size depends on the speed of the external clock we connect to the CLK pin.
5. Activate OE (output enable) to read data out of the ADC chip.

   *Note:* In ADC0808 that there is no self-clocking and the clock must be provided from an external source to the CLK pin. Although the speed of conversion depends on the frequency of the clock connected to the CLK pin, it cannot be faster than 100 microseconds.

**Step 2-Flow Chart**

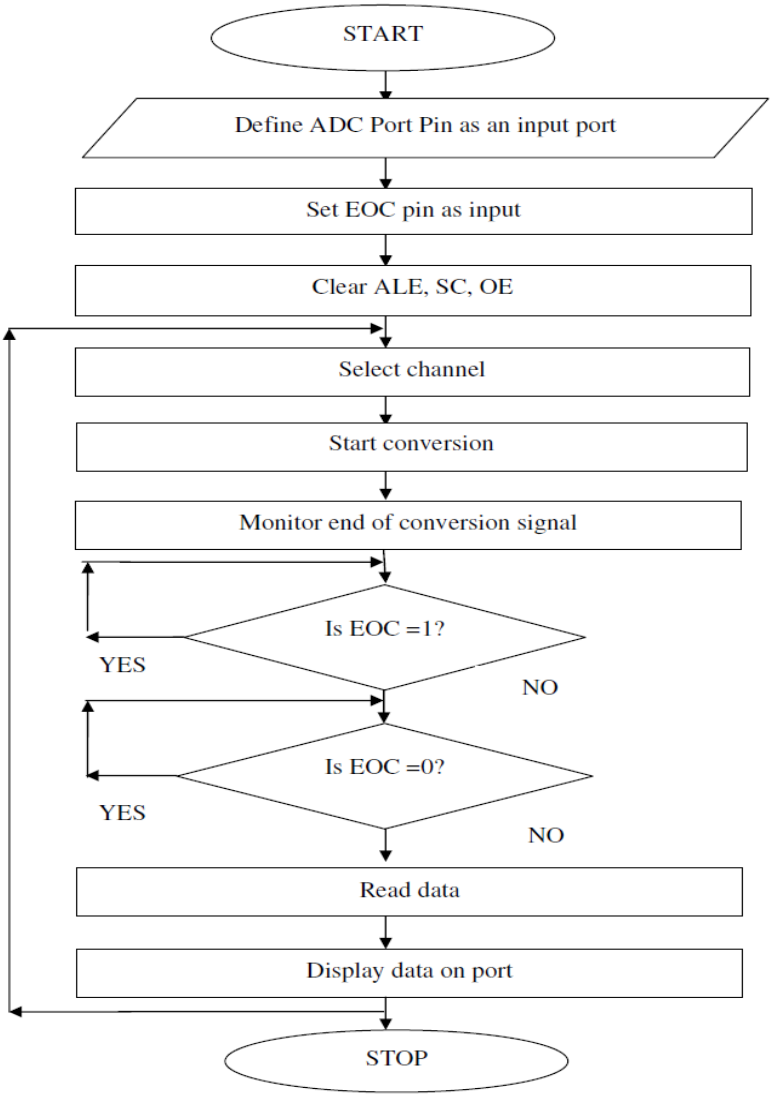


**Fig 22.5 Flowchart to display the key pressed on LCD**

**Step 3-Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | Starting address |
| C:0X0000 | 7590FF | | MOV P1, #0FFH | Makes port 1 input port |
| C:0X0003 | D2A7 | | SETB P2.7 | Makes EOC pin high |
| C:0X0005 | C2A4 | | CLR P2.4 | Clears ALE pin |
| C:0X0007 | C2A6 | | CLR P2.6 | Clears start pin |
| C:0X009 | C2A5 | | CLR P2.5 | Clear OE pin |
| C:0X000B | C2A2 | BACK: | CLR P2.2 | Clears ADD C |
| C:0X000D | D2A1 | | SETB P2.1 | Sets ADD B |
| C:0X000F | C2A0 | | CLR P2.0 | Clears ADD A (this selects the second address line) |
| C:0X0011 | 112F | | ACALL DELAY | |
| C:0X0013 | D2A4 | | SETB P2.4 | Sets ALE high |
| C:0X0015 | 112F | | ACALL DELAY | |
| C:0X0017 | D2A6 | | SETB P.26 | Sends a command to start of conversion pulse. |
| C:0X0019 | 112F | | ACALL DELAY | |
| C:0X001B | C2A4 | | CLR P2.4 | Makes ALE low |
| C:0X001D | C2A6 | | CLR P2.6 | Makes start pin low |
| C:0X001F | 20A7FD | HERE: | JB P2.7, HERE | Waits for low pulse at EOC |
| C:0X0022 | 30A7FD | HERE1: | JNB P2.7, HERE1 | Waits for low pulse to finish |
| C:0X0025 | D2A5 | | SETB P2.5 | Enables OE pin to extract data from ADC |
| C:0X0027 | 112F | | ACALL DELAY | |
| C:0X0029 | E590 | | MOV A, P1 | Moves acquired data to accumulator |
| C:0X002B | C2A5 | | CLR P2.5 | Clears OE |
| C:0X002D | 80DC | | SJMP BACK | Repeatedly gets data from ADC |
| C:0X002F | 7B32 | DELAY: | MOV R3, #50 | |
| C:0X0031 | 7CFF | HERE2: | MOV R4, #255 | |
| C:0X0033 | DCFE | | DJNZ R4, HERE3 | |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C;0X0035 | DBFA | | DJNZ R3, HERE 2 | |
| C:0X0037 | | | RET | |
| | | | END | |

**XI Resources Used:**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |

**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

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**XIII Observations for sample program** (use blank sheet provided if space not sufficient)

| Input Voltage | Output HEX Value observed on LED's |
|---|---|
| **1V** | |
| **2V** | |
| **3V** | |
| **4V** | |
| **5V** | |

**XIV Results** (Output of the Program)

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**XV Interpretation of Results** (Give meaning of the above obtained results)

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**XVI Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

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**XVII Practical Related Questions**

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

1. List two applications where serial ADC and parallel ADC chips are used.
2. Draw timing diagram for entire ADC process.
3. Distinguish ADC 0804, ADC 0808 and ADC 0848.
4. Give the pin functions of ADC 0808.

**[Space for Answers]**

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## XVIII References / Suggestions for further reading

1. https://technobyte.org/8051-interfacing-adc-0808-tutorial-steps/#Where_is_an_Analog-to-Digital_Converter_ADC_used
2. https://www.circuitstoday.com/interfacing-adc-to-8051
3. https://microcontrollerslab.com/interfacing-adc-0804-8051-microcontroller/

## XIX Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40% (10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 % (25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 23: DAC interfacing to generate the square waveform.

## I Practical Significance

The digital to analog converter (DAC) is a device widely used to convert digital pulses to analog signals. This practical will help the students to develop skills to interface DAC with 8051 and generate different analog waveforms.

## II Industry/Employer expected outcome(s)

Maintain microcontroller-based systems.

## III Course Level Learning Outcome(s)

Maintain microcontroller based applications.

## IV Laboratory Learning Outcome(s)

Interface DAC with 8051 microcontroller and generate square waveform.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

The Digital to Analog converter (DAC) is a device, that is widely used for converting digital pulses to analog signals. There are two methods of converting digital signals to analog signals.

1. Binary weighted method and
2. R/2R ladder method.

R/2R ladder is the widely used method. This method can achieve a much higher degree of precision. DACs are judged by its resolution. The resolution is a function of the number of binary inputs. The most common input counts are 8, 10, 12 etc. Number of data inputs decides the resolution of DAC. So, if there are n digital input pin, there are $2^n$ analog levels. So, 8 input DAC has 256 discrete voltage levels.

he output current is known as Iout by connecting a resistor to the output to convert into voltage. The total current provided by the Iout pin is basically a function of the binary numbers at the input pins D0 - D7 (D0 is the LSB and D7 is the MSB) of DAC0808 and the reference current Iref. The following formula is showing the function of Iout:

$$I_{out} = I_{ref}\left(\frac{D_7}{2} + \frac{D_6}{4} + \frac{D_5}{8} + \frac{D_4}{16} + \frac{D_3}{32} + \frac{D_2}{64} + \frac{D_1}{128} + \frac{D_0}{256}\right)$$

The Iref is the input current. This must be provided into the pin 14. Generally, 2.0mA is used as Iref. Iout pin is connected to the resistor to convert the current to voltage.

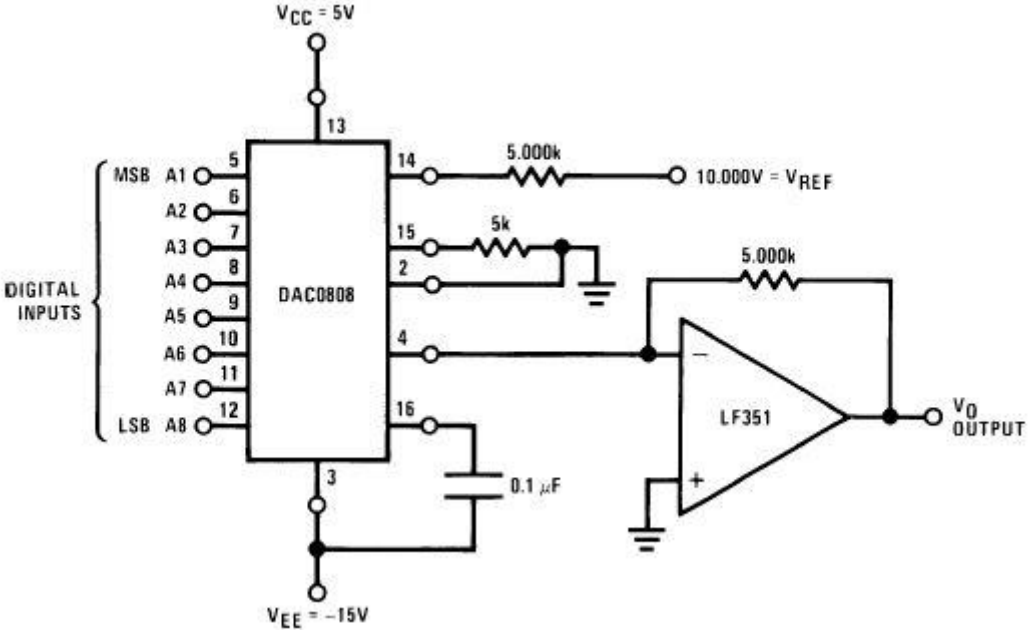


**Fig 23.1: DAC Block Diagram**

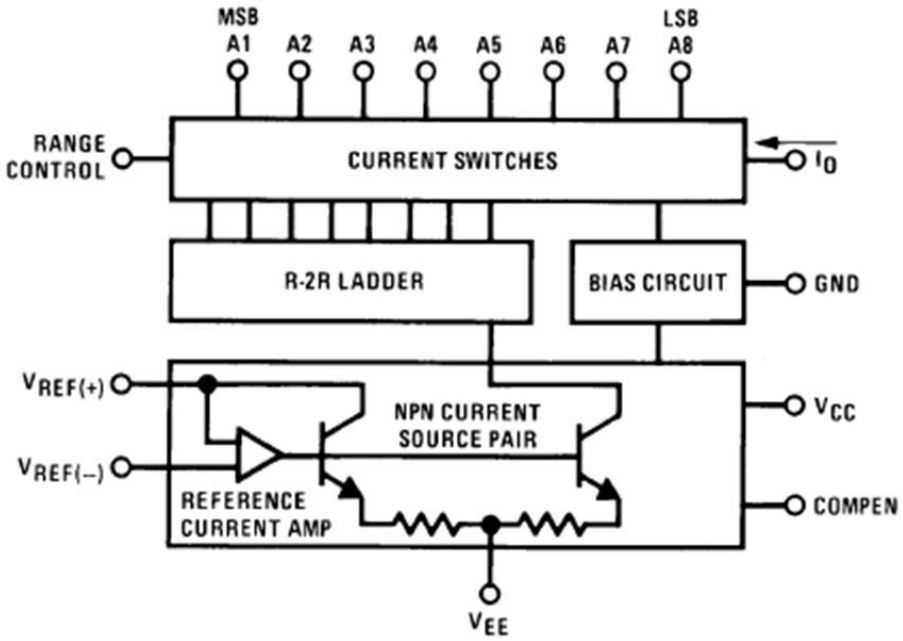


**Fig 23.2: DAC Block Diagram**

**Specifications DAC 0808 Chip**

1. Resolution: 8 bits
2. Settling Time: Typically, 100 nanoseconds
3. Output Current: Up to 1.999 mA
4. Voltage Supply: +5V or ±5V to ±18V
5. Accuracy: ±0.19% of full scale
6. Output Type: Voltage output
7. Compatibility: TTL/CMOS

## VII Actual Circuit Diagram used in laboratory

### a) Sample Circuit Diagram

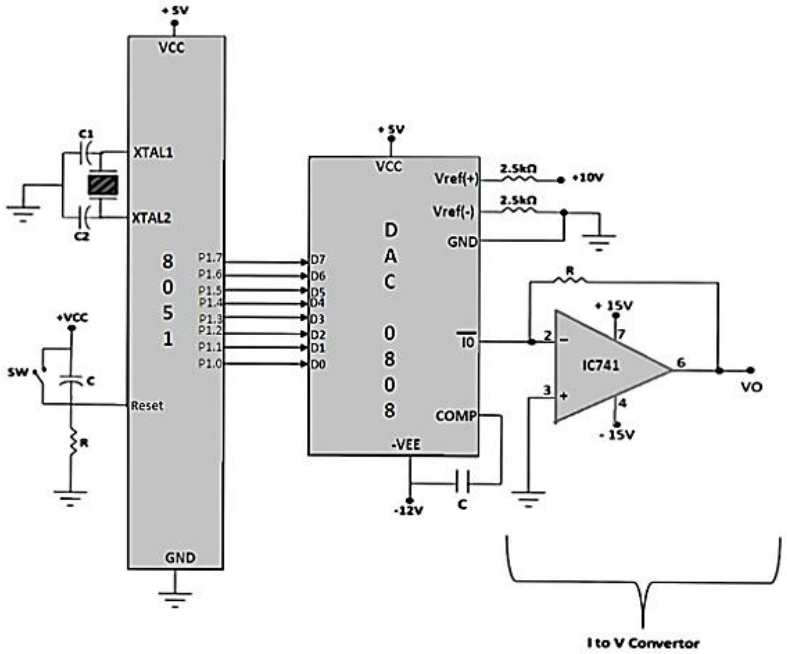


**Fig 23.3 DAC interfacing to 8051**

### b) Practical Setup:

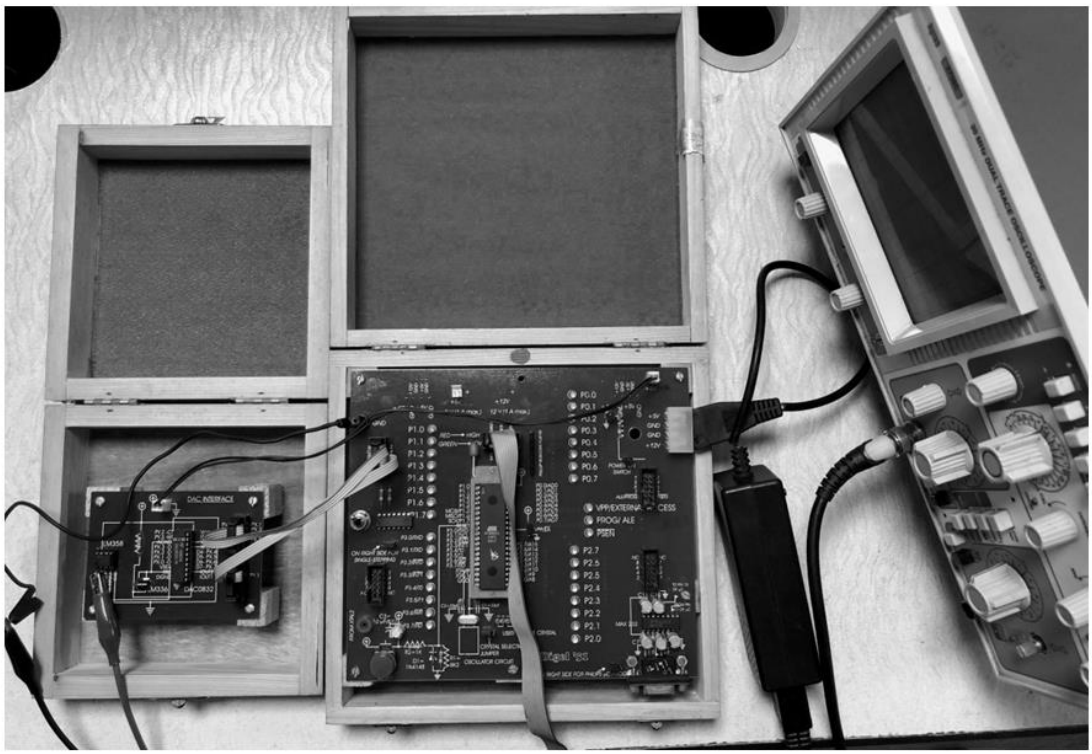

**Fig 23.4 Practical Set up Diagram**

### c) Simulation Diagram:

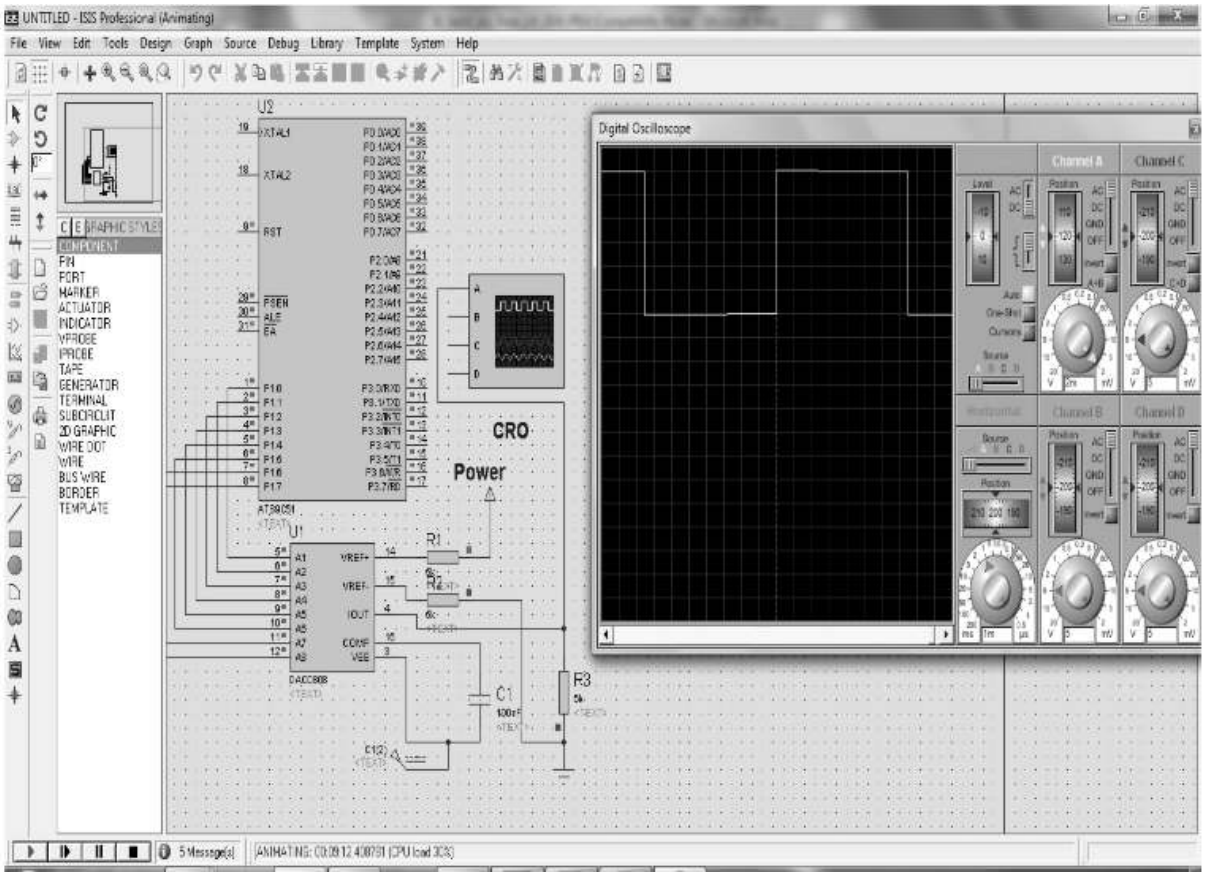


**Fig 23.5: Simulation Diagram**

### d) Actual Circuit Diagram used:

## VIII Resources Required

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1 | Microcontroller kit | Single board systems with 8K RAM,ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler,RS-232,USB, interfacing facility with built in power supply. | 1 No. |
| 2 | Desktop PC | Loaded with open source IDE, simulation and program downloading software | 1 No. |
| 3 | DAC (0808) trainer board | Suitable to interface 8051 board. | 1 No |

## IX Precautions to be Followed

1. Check rules / syntax of assembly programming.
2. Operate DAC chip as per specifications given in the datasheet otherwise damage may occur to the device.

## X Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL and select AT89C51.
5. Type the program in text editor and save as filename.asm extension.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window.
11. Note the values of the result of various operations in the observation table.

## E-Waste Management

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: Write a program to generate square waveform using DAC.

**STEP1- Algorithm**

1. Make the Port used to Interface DAC as an output port.
2. Clear Accumulator.
3. Send 00H value to Port 1

4. Call Delay
5. Send FFH value to port 1
6. Call Delay.
7. For repeat operation go to step3.

**Step 2-Flow Chart**

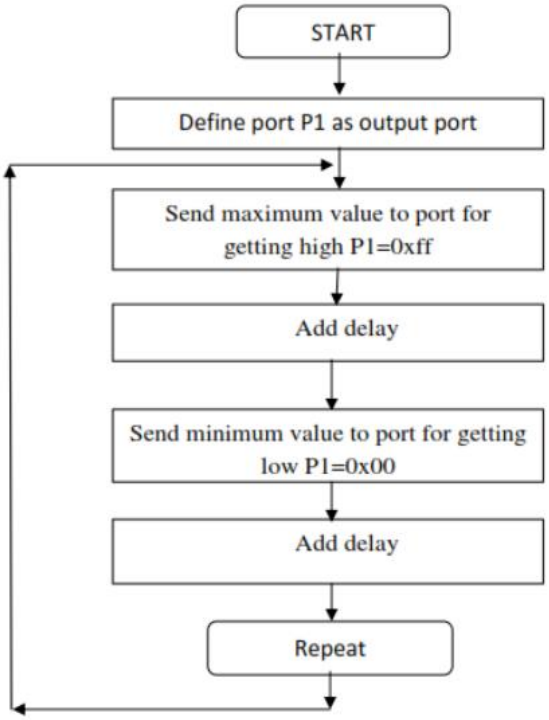


**Fig 23.6 Flowchart to generate Square waveform**

**Step 3-Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000h | |
| C:0x0000 | 7400 | MAIN: | MOV A, #00h | Clear A |
| C:0x0002 | F590 | | MOV P1, A | Send value to P1 |
| C:0x0004 | 110E | | ACALL DELAY | Call Delay |
| C:0x0006 | 74FF | | MOV A, #FFH | Move Highest value in Accumulator |
| C:0x0008 | F590 | | MOV P1, A | Send value to P1 |
| C:0x000A | 110E | | ACALL DELAY | Decrement value |
| C:0x000C | | | SJMP MAIN | Compare with lowest value |
| | | DELAY | | |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x000E | 78FF | | MOV R0, #100 | Initialize Delay register |
| C:0X0010 | 79FF | HERE 1: | MOV R1, #100 | |
| C:0x0012 | D9FE | HERE: | DJNZ R1, HERE | Repeat till R1 becomes zero |
| C:0X0014 | D8FA | | DJNZ R0, HERE1 | Repeat till R1 becomes zero |
| C:0X0016 | 22 | | RET | |
| | | | END | |

**Problem statement for student:** Develop assembly program to generate a square wave with ON time of 3msec and OFF time of 5 msec. {Assume suitable crystal frequency}

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

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| | |

**XI Resources Used:**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |

**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

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**XIII Observations for sample program** (use blank sheet provided if space not sufficient)
Trace the waveform for the square waveform observed on CRO.

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**XIV Results** (Output of the Program)

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**XV Interpretation of Results (**Give meaning of the above obtained results)

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**XVI Conclusions and Recommendation (**Actions/decisions to be taken based on the interpretation of results).

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**XVII Practical Related Questions**

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

1. If Iref = 2mA and all the inputs to the DAC are high then find maximum current of DAC 0808 IC.
2. Define Duty cycle for the square waveform.
3. Write a program for generating a square waveform for 60% duty cycle.

**[Space for Answers]**

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## XVIII References / Suggestions for further reading


1. https://www.tutorialspoint.com/interfacing-dac-with-8051-microcontroller
2. http://vlabs.iitkgp.ac.in/rtes/exp3/index.html
3. https://peripheralinterfacing.wordpress.com/digital-to-analog-converter-using-8051-microcontroller/


## XIX Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40% (10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 % (25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 24: DAC interfacing to generate the triangular waveform.

## I Practical Significance

The digital to analog converter (DAC) is a device widely used to convert digital pulses to analog signals. This practical will help the students to develop skills to interface DAC with 8051 and generate different analog waveforms.

## II Industry/Employer expected outcome(s)

Maintain microcontroller-based systems.

## III Course Level Learning Outcome(s)

Maintain microcontroller based applications.

## IV Laboratory Learning Outcome(s)

Interface DAC with 8051 microcontroller and generate triangular, saw-tooth waveform.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

The Digital to Analog converter (DAC) is a device, that is widely used for converting digital pulses to analog signals. There are two methods of converting digital signals to analog signals.

1. Binary weighted method and
2. R/2R ladder method.

R/2R ladder is the widely used method. This method can achieve a much higher degree of precision. DACs are judged by its resolution. The resolution is a function of the number of binary inputs. The most common input counts are 8, 10, 12 etc. Number of data inputs decides the resolution of DAC. So, if there are n digital input pin, there are $2^n$ analog levels. So, 8 input DAC has 256 discrete voltage levels.

he output current is known as Iout by connecting a resistor to the output to convert into voltage. The total current provided by the Iout pin is basically a function of the binary numbers at the input pins D0 - D7 (D0 is the LSB and D7 is the MSB) of DAC0808 and the reference current Iref. The following formula is showing the function of Iout:

$$I_{out} = I_{ref}\left(\frac{D_7}{2} + \frac{D_6}{4} + \frac{D_5}{8} + \frac{D_4}{16} + \frac{D_3}{32} + \frac{D_2}{64} + \frac{D_1}{128} + \frac{D_0}{256}\right)$$

The Iref is the input current. This must be provided into the pin 14. Generally, 2.0mA is used as Iref. Iout pin is connected to the resistor to convert the current to voltage.

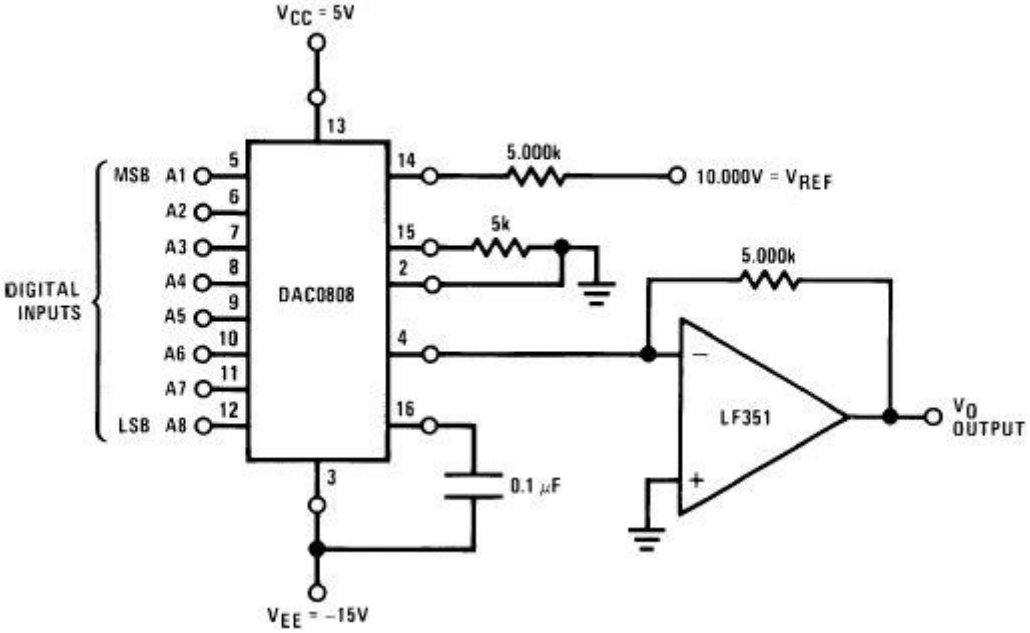


**Fig 24.1: DAC Block Diagram**

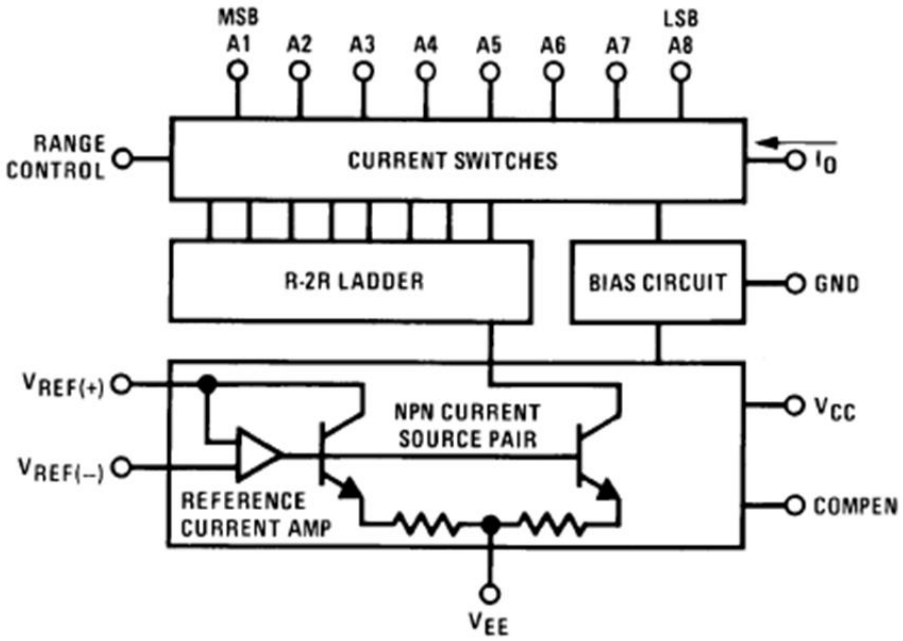


**Fig 24.2: DAC Block Diagram**

**Specifications DAC 0808 Chip**

1. Resolution: 8 bits
2. Settling Time: Typically, 100 nanoseconds
3. Output Current: Up to 1.999 mA
4. Voltage Supply: +5V or ±5V to ±18V
5. Accuracy: ±0.19% of full scale
6. Output Type: Voltage output
7. Compatibility: TTL/CMOS

## VII Actual Circuit Diagram used in laboratory

### a) Sample Circuit Diagram

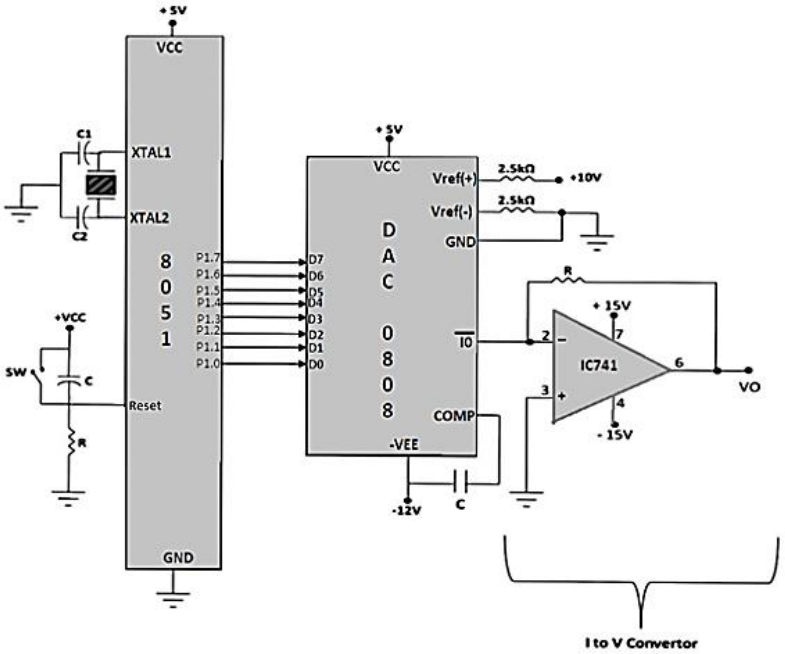


**Fig 24.3 DAC interfacing to 8051**

### b) Practical Setup:

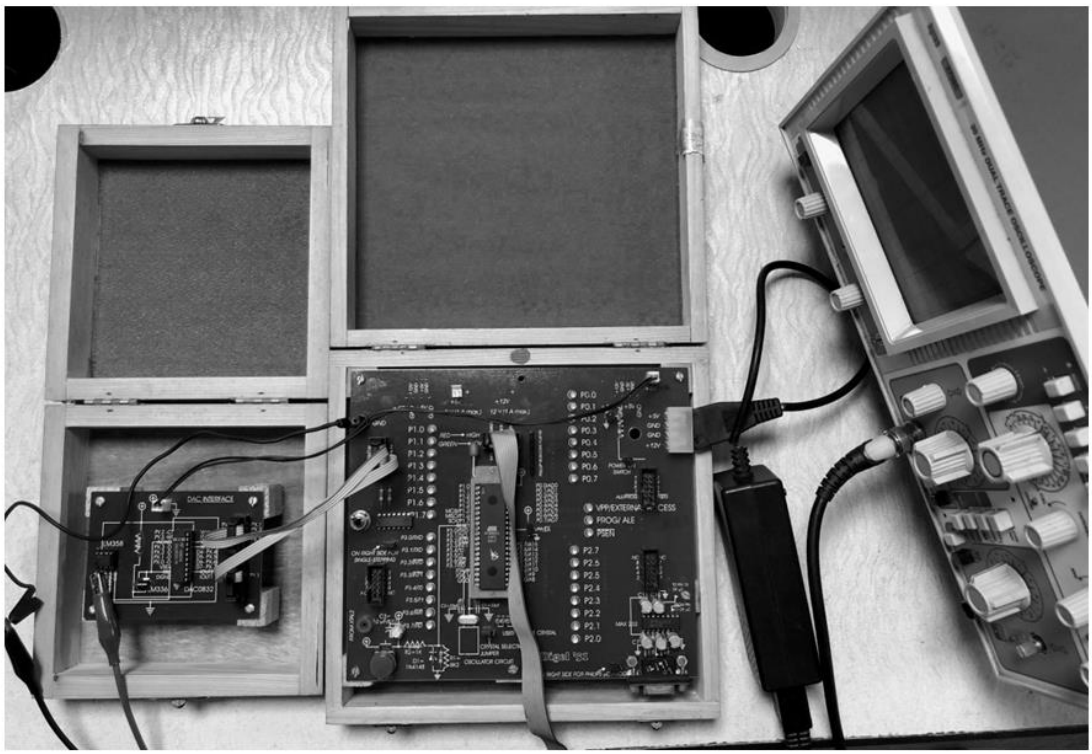

**Fig 24.4 Practical Set up Diagram**

**c) Simulation Diagram:**

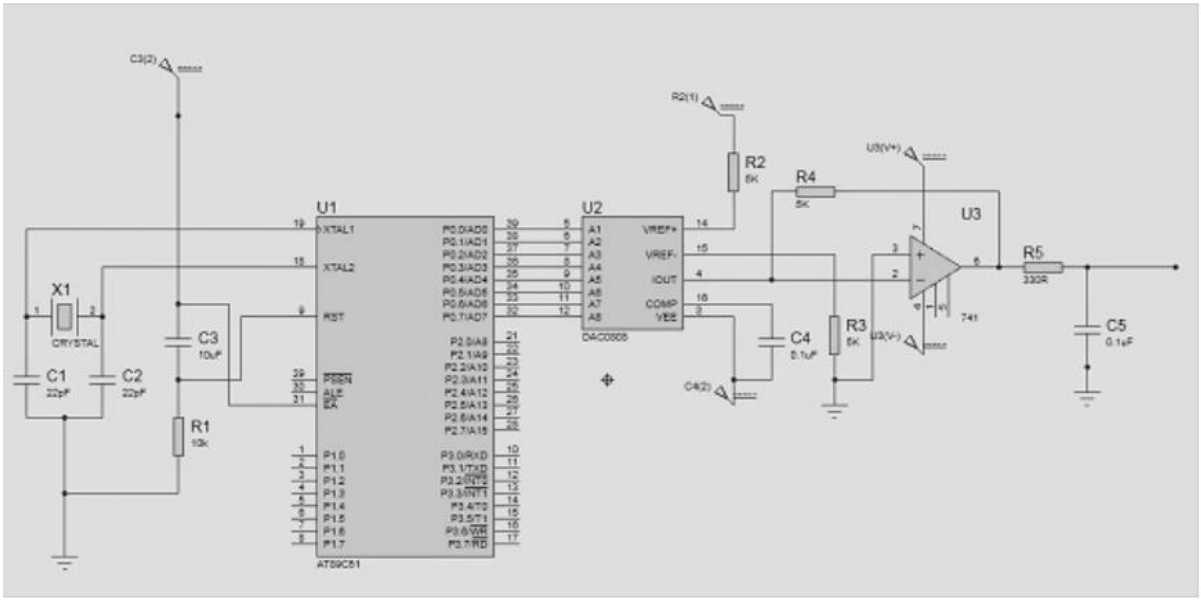


**Fig 24.5: Simulation Diagram**

**d) Actual Circuit Diagram used:**

## VIII Resources Required

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1 | Microcontroller kit | Single board systems with 8K RAM, ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler, RS-232, USB, interfacing facility with built in power supply. | 1 No. |
| 2 | Desktop PC | Loaded with open-source IDE, simulation and program downloading software | 1 No. |
| 3 | DAC (0808) trainer board | Suitable to interface 8051 board. | 1 No |

## IX Precautions to be Followed

1. Check rules / syntax of assembly programming.
2. Operate DAC chip as per specifications given in the datasheet otherwise damage may occur to the device.

## X Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL and select AT89C51.
5. Type the program in text editor and save as filename.asm extension.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window.
11. Note the values of the result of various operations in the observation table.

## E-Waste Management

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: Write a program to generate triangular waveform using DAC.

**STEP1- Algorithm**

1. Make the Port used to Interface DAC as an output port.
2. Clear Accumulator.
3. Send 00H value to DAC
4. Increment value.
5. Compare current value with highest value 0FFh and send it to DAC till it reaches.
6. Decrement value.
7. Compare current value with lowest value 00H and send it to DAC till it reaches.
8. For repeat operation go to step3.
9. Stop.

**Step 2-Flow Chart**

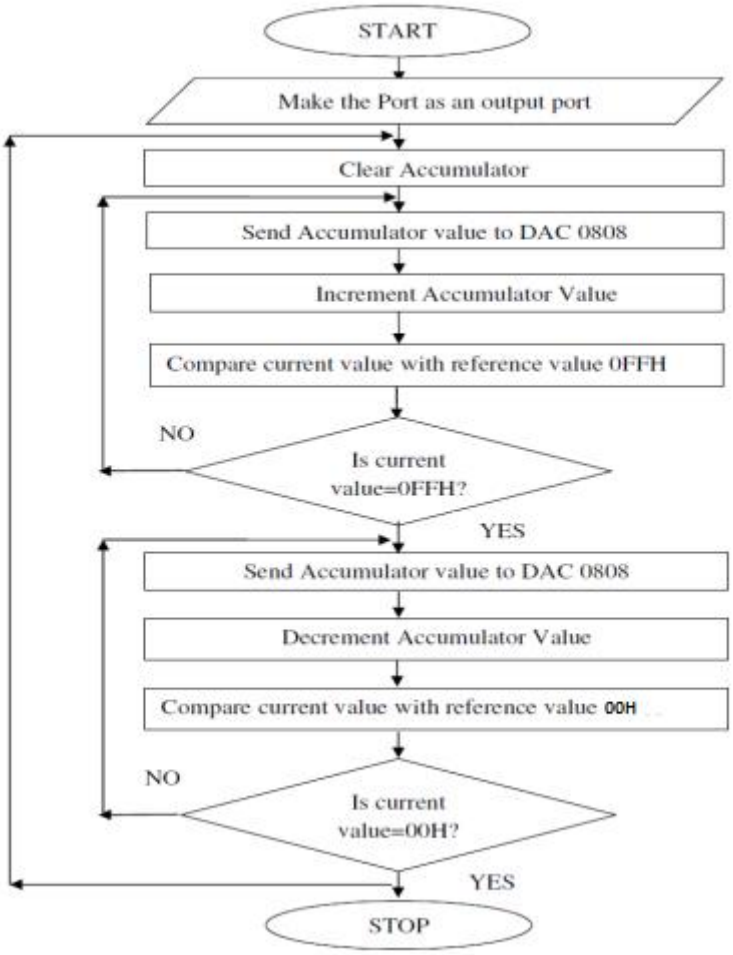


**Fig 24.6 Flowchart to generate triangular waveform**

**Step 3-Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000h | |
| C:0x0000 | 7400 | REPEAT: | MOV A, #00h | Clear A |
| C:0x0002 | F590 | INCR: | MOV P0, A | Send value to P1 |
| C:0x0004 | 04 | | INC A | Increment value |
| C:0x0005 | B4FFFA | | CJNE A,#0FFh,INCR | Compare with highest value |
| C:0x0008 | F590 | DECR: | MOV P0, A | Send value to P1 |
| C:0x000A | 14 | | DEC A | Decrement value |
| C:0x000B | B400FA | | CJNE A, #00h, DECR | Compare with lowest value |
| C:0x000E | 80F0 | | SJMP REPEAT | Repeat |
| | | | END | |

**Problem statement for student:** Develop assembly program to generate sawtooth waveform using DAC 0808

| Step 1-Algorithm | Step 2-Flowchart |
|---|---|
| | |

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| | |

**XI Resources Used:**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |

**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

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**XIII Observations for sample program** (use blank sheet provided if space not sufficient)
Trace the waveform for the triangular waveform observed on CRO.

**XIV Results** (Output of the Program)

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**XV Interpretation of Results** (Give meaning of the above obtained results)

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**XVI Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

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**XVII Practical Related Questions**

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

1. If Iref = 2mA and all the inputs to the DAC are high then find maximum current of DAC 0808 IC.
2. To generate a sine wave using DAC 0808 find decimal values representing magnitude of
the sine of angles between 0 and 360 degrees.
Refer Vout = 5V+ (5xsinθ).

3. If a switch SW is connected to port pin P0.0. Write a program to do the following.
   **a)** When SW=0 the DAC output gives a triangular waveform.
   **b)** When SW=1 the DAC output gives a staircase waveform.

**[Space for Answers]**

## XVIII References / Suggestions for further reading

1. https://www.tutorialspoint.com/interfacing-dac-with-8051-microcontroller
2. http://vlabs.iitkgp.ac.in/rtes/exp3/index.html

3. https://peripheralinterfacing.wordpress.com/digital-to-analog-converter-using-8051-microcontroller/

## XIX Assessment Scheme

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40% (10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 % (25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 25: Stepper Motor interfacing to 8051

## I Practical Significance

Stepper motors are commonly used in a wide range of applications such as robotics, CNC machines, 3D printers, medical equipment, and automated manufacturing machinery where precise speed control and accuracy are necessary. Stepper motors are controlled by microcontrollers in areas such as computer peripherals, Business machines, process control and for making robots. This practical will help the students to develop skills to interface stepper motor to 8051 and rotate in clockwise direction at the given angles

## II Industry/Employer Expected Outcome(s)

Maintain microcontroller based systems.

## III Course Level Learning Outcome(s)

Maintain microcontroller based applications

## IV Laboratory Learning Outcome(s)

Interface stepper motor to microcontroller and rotate in clockwise direction at the given angles

## V Relevant Affective Domain related outcome(s)

1. Follow safe practices.
2. Maintain tools and equipment.
3. Follow ethical practices.

## V I Relevant Theoretical Background

Stepper motor converts electrical energy into precise mechanical motion. It rotates a specific incremental distance per step. Every discrete step of a stepper motor is measured in degree (it can be 1.8° or even smaller depending on the stepper motor type and stepping technique).

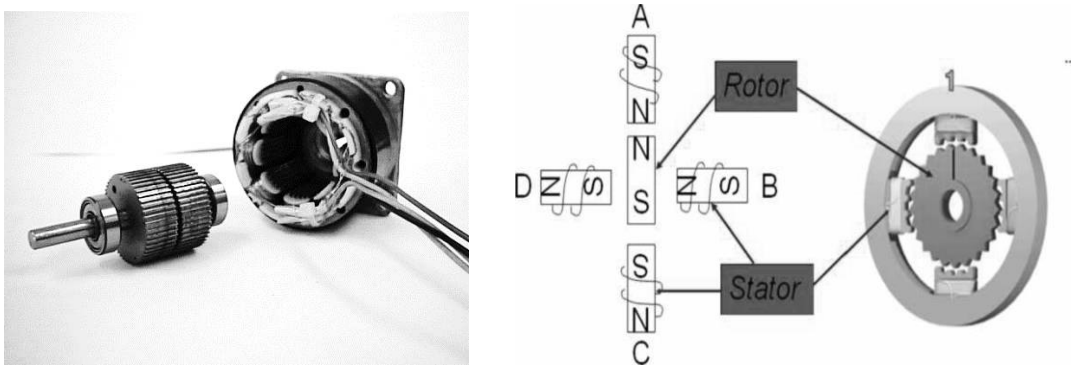


**Fig.25.1 Construction of stepper motor**

It works on the principle of electromagnetism. There is a magnetic rotor shaft of soft iron which is surrounded by the electromagnetic stators. When the stators are energized the rotor moves to align itself along with the stator (in case of a permanent magnet type stepper) or moves to have a minimum gap with the stator (in case of variable reluctance stepper). In this way the stators are energized in a sequence to rotate stepper motor

Generally, stepper motors are classified into two types according to windings as:

- Unipolar
- Bipolar

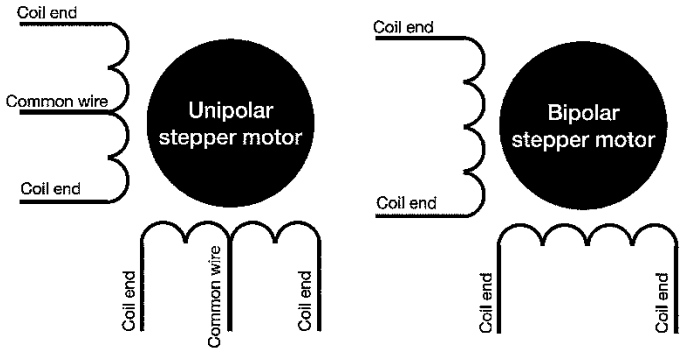


**Fig.25.2 Stepper motor types**

The unipolar stepper motors, has one winding per phase, with a center tap. It has five or six wires and four coils (actually two coils divided by center connections on each coil). The centre connections of the coils are tied together and used as the power connection. They are called unipolar stepper motors because power always comes in one pole.
The Bipolar stepper motor has four wires with no common center connection. It has two independent sets of coils.

**Step angle:**
Step angle is defined as the minimum degree of rotation with a single step.
**Number of steps per revolution =** 360° / step angle
**Steps per second =** (RPM x steps per revolution) / 60

**Table 18.1 Stepper Motor Step Angles**

| Step Angle | Steps per revolution |
|---|---|
| 0.72 | 500 |
| 1.8 | 200 |
| 2.0 | 180 |
| 2.5 | 144 |
| 5 | 72 |

**Switching Sequence of Motor**:
As the coils need to be energized for the rotation. This can be done by sending a bits sequence to one end of the coil while the other end is commonly connected. The bit sequence sent can make either one phase ON or two phase ON for a full step sequence or it can be a combination of one and two phase ON for half step sequence.

**Full Step Sequence:**

a) Wave Drive Stepping Mode (ONE PHASE ON )

| Clockwise | Step # | Winding A | Winding B | Winding C | Winding D | Anti-Clockwise |
|---|---|---|---|---|---|---|
| ↓ | 1 | 1 | 0 | 0 | 0 | ↑ |
| | 2 | 0 | 1 | 0 | 0 | |
| | 3 | 0 | 0 | 1 | 0 | |
| | 4 | 0 | 0 | 0 | 1 | |

**b.** Full Drive Stepping Mode (TWO PHASE ON)

| Clockwise | Step # | Winding A | Winding B | Winding C | Winding D | Anti-Clockwise |
|---|---|---|---|---|---|---|
| ↓ | 1 | 1 | 0 | 0 | 1 | ↑ |
| | 2 | 1 | 1 | 0 | 0 | |
| | 3 | 0 | 1 | 1 | 0 | |
| | 4 | 0 | 0 | 1 | 1 | |

**Half Step Sequence:**

- Half Drive mode:

To allow for finer resolution, all stepper motors allow an 8-step switching sequence.

| Clockwise | Step | Winding A | Winding B | Winding C | Winding D | Clockwise |
|---|---|---|---|---|---|---|
| ↓ | 1 | 1 | 0 | 0 | 1 | ↑ |
| | 2 | 1 | 0 | 0 | 0 | |
| | 3 | 1 | 1 | 0 | 0 | |
| | 4 | 0 | 1 | 0 | 0 | |
| | 5 | 0 | 1 | 1 | 0 | |
| | 6 | 0 | 0 | 1 | 0 | |
| | 7 | 0 | 0 | 1 | 1 | |
| | 8 | 0 | 0 | 0 | 1 | |

## VII Practical Circuit diagram:

a) Sample circuit diagram

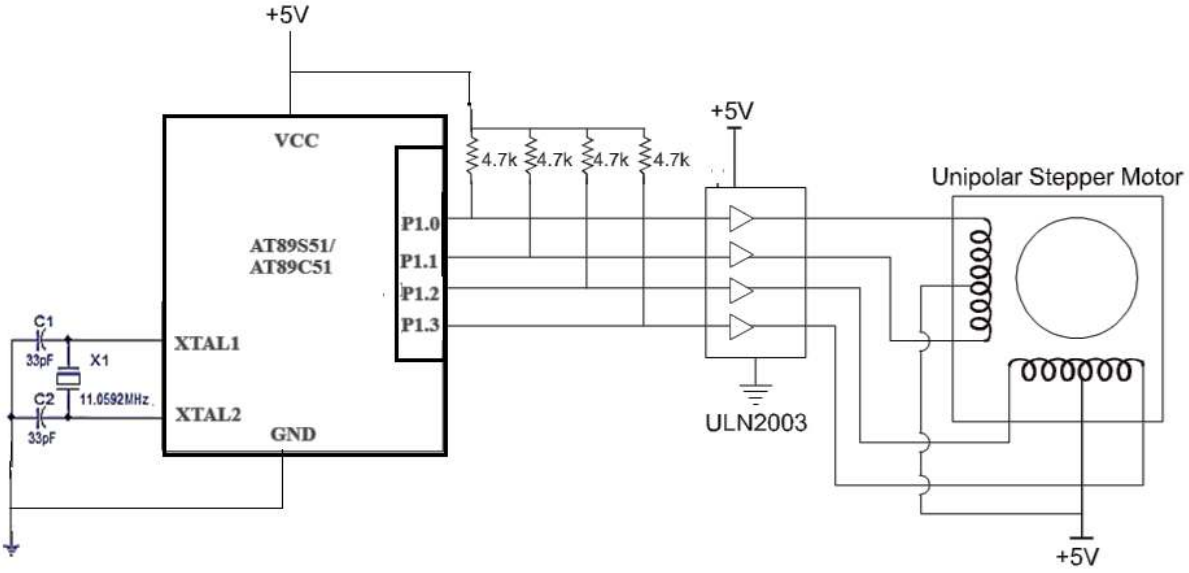


**Fig 25.3 8051 connection to stepper motor**

b) Practical setup

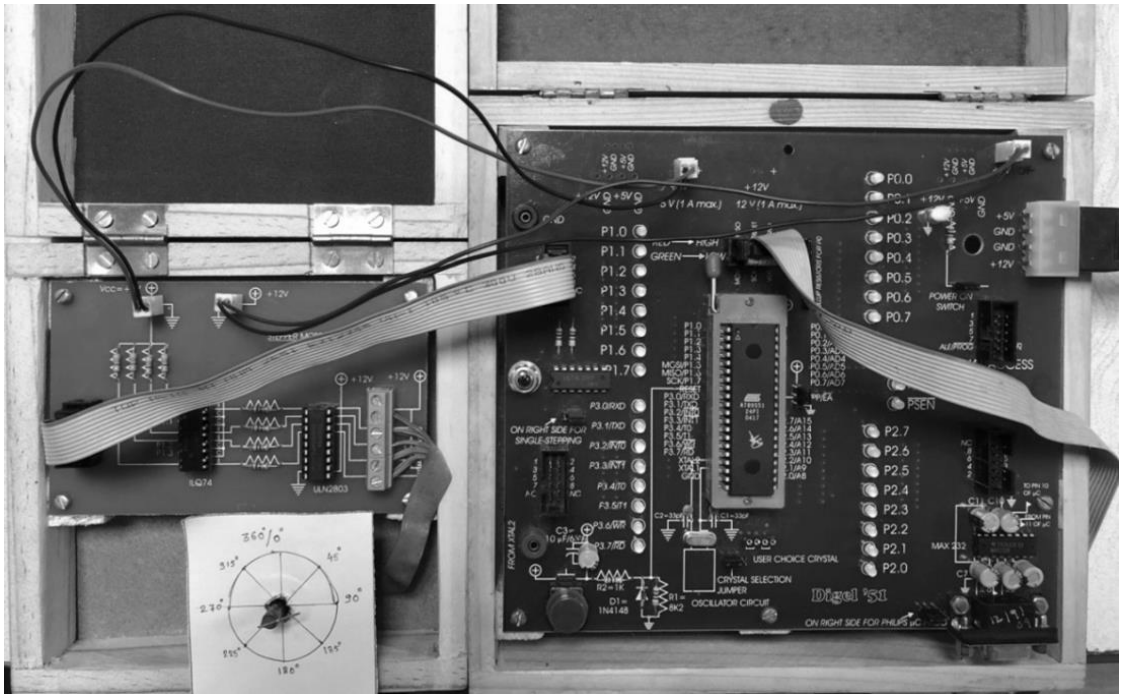

**Fig 25.4 Practical Setup**

c) Simulation diagram

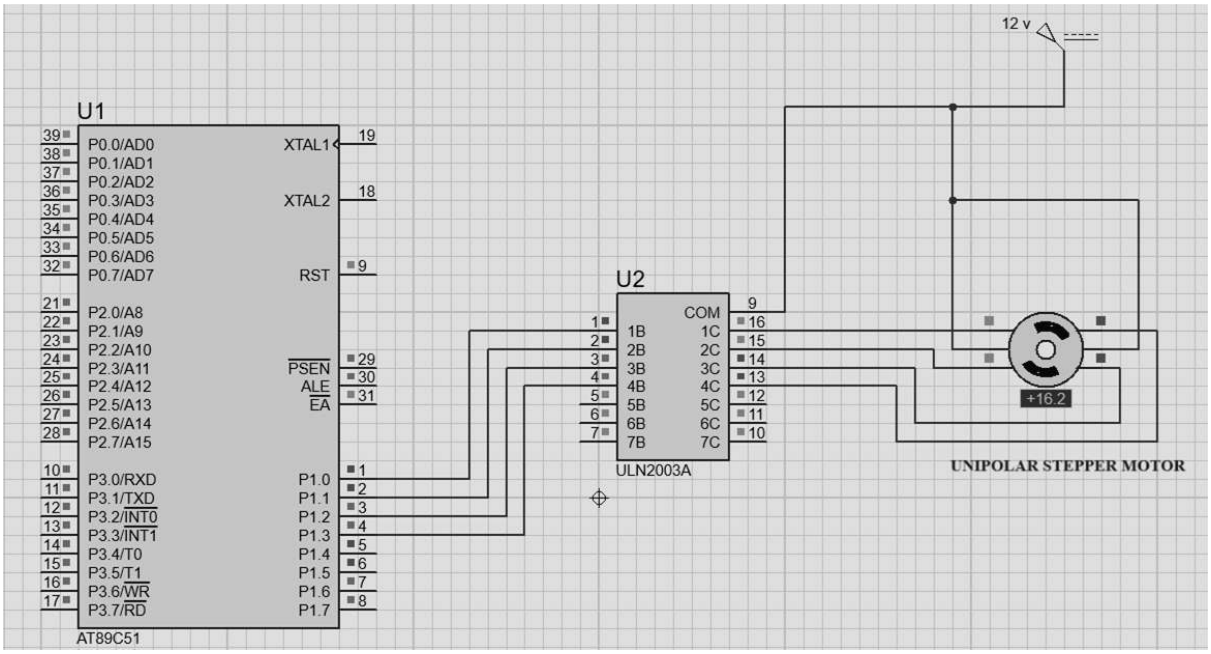


**Fig 25.5 Simulation diagram**

d) Actual circuit used in laboratory

e) Actual Experimental set up used in laboratory

## VIII Required Resources/apparatus/equipment with specifications

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Microcontroller kit | Single board system with 8K RAM,ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross C-compiler,RS-232,USB, interfacing facility with built in power supply. | 1 No. |
| 2. | Desktop PC | Loaded with open source IDE, simulation and program downloading software. | 1 No. |
| 3. | Stepper Motor Trainer | 1.8° Step angle, 50/100 RPM Stepper motor with ULN 2003/2803 Driver. | No. |

## IX Precautions to be followed

1) Ensure proper connection before turning ON power supply to the kit.
2) Always use driver circuit while interfacing stepper motor to microcontroller.
3) Check rules / syntax of assembly language programming.

## X Procedure

1. Write algorithm for given problem.
2. Draw flowchart for the same.
3. Develop assembly program using Integrated Development Environment (IDE) or any other relevant software tool.
4. Debug program on IDE.
5. Execute program on IDE.
6. Create hex file for the above program.
7. Download hex code in EPROM/Flash memory of the microcontroller.
8. Interface stepper motor to microcontroller as per circuit diagram shown in fig 25.3
9. Observe rotation of stepper motor and record in observation Table.

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM**: Write a program to rotate stepper motor in clockwise direction by $360^0$
Assume step angle of $1.8^o$

**Step 1-Algorithm**

1. Initialize the Port used to Interface stepper motor as an output port.
2. Set register as counter R1=50 for 200 steps i.e. 360° rotation.
3. Send first step sequence to stepper motor and add delay
4. Send second step sequence to stepper motor and add delay
5. Send third step sequence to stepper motor and add delay
6. Send fourth step sequence to stepper motor and add delay
7. Decrement counter and if count ≠ 0, go to step 3
8. Stop

**Step 2-Flow Chart**

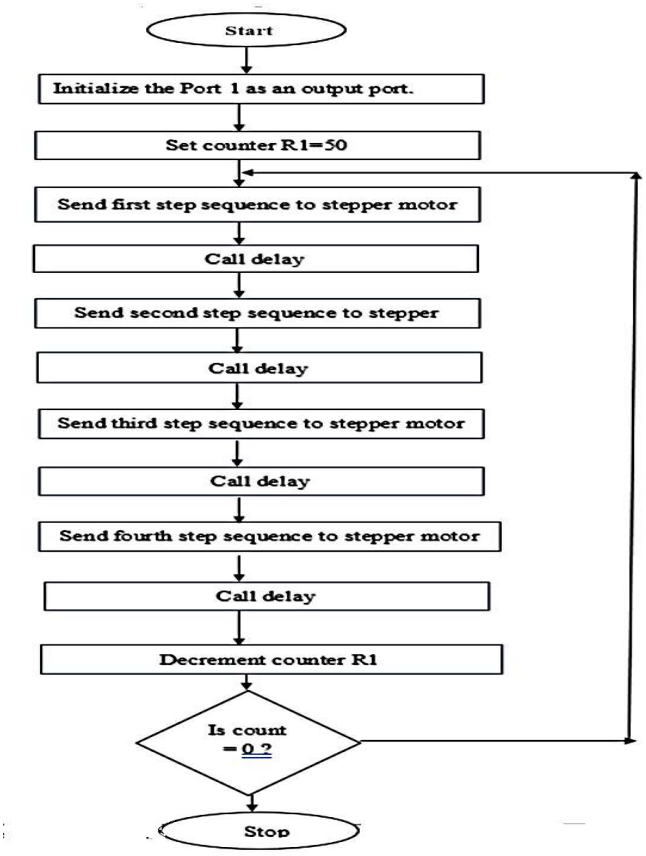


**Fig 25.6 Flowchart for stepper motor to rotate in clockwise direction by $360^o$**

**Step 3-Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | |
| C:0x0000 | 7932 | | MOV R1,#50 | ; Load count =50 for $360^0$ rotation |
| C:0x0002 | 759099 | UP: | MOV P1,#99H | ; Send first step sequence to Port 1 |
| C:0x0005 | 111A | | ACALL DELAY | ; Call delay subroutine |
| C:0x0007 | 7590CC | | MOV P1,#0CCH | ; Send second step sequence to Port 1 |
| C:0x000A | 111A | | ACALL DELAY | ; Call delay subroutine |
| C:0x000C | 759066 | | MOV P1,#66H | ; Send third step sequence to Port 1 |
| C:0x000F | 111A | | ACALL DELAY | ; Call delay subroutine |
| C:0x0011 | 759033 | | MOV P1,#33H | ; Send fourth step sequence to Port 1 |
| C:0x0014 | 111A | | ACALL DELAY | ; Call delay subroutine |
| C:0x0016 | D9EA | | DJNZ R1,UP | ;Repeat 50 times |
| C:0x0018 | 80FE | HERE: | SJMP HERE | ;stop |
| C:0x001A | 7BFF | DELAY: | MOV R3,#255 | ;Delay subroutine |
| C:0x001C | 7CFF | L2: | MOV R4,#255 | |
| C:0x001E | DCFE | L1: | DJNZ R4,L1 | |
| C:0x0020 | DBFA | | DJNZ R3,L2 | |
| C:0x0022 | 22 | | RET | |
| | | | END | |

**Problem statement for student**: Write a program to rotate stepper motor in clockwise direction by $180^{0.}$ Use Full step sequence

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
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**X I Resources used**

| Sr. No. | Name of Resource | Specifications | Quantity |
|---|---|---|---|
| | | | |
| | | | |

**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……

**XIII Observations sample program** (use blank sheet provided if space not sufficient)

| Steps | Step code | Port pin status ( 0 / 1 ) | | | |
|---|---|---|---|---|---|
| | | P1.3 | P1.2 | P1.1 | P1.0 |
| **Step 1** | | | | | |
| **Step 2** | | | | | |
| **Step 3** | | | | | |
| **Step 4** | | | | | |

**XIV Results (Output of the Program)**

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……

**XV Interpretation of Results (Give meaning of the above obtained results)**

……..…

…….

**XVI Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

……..……..

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**XVII Practical related questions**

***Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.***

1. Calculate no of steps to move stepper motor by 40 degree in clockwise direction if step angle is 2 degree, steps per revolution =180.
2. A stepper motor has a step angle of 7.2 degrees. Calculate number of steps per revolution.
3. Give the 8-step sequence of a stepper motor if code start with 0010.

**[Space for Answers]**

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## XVIII References/Suggestions for further reading


1. https://www.monolithicpower.com/learning/resources/stepper-motors-basics-types-uses
2. https://www.portescap.com/en/products/stepper-motor-control
3. http://vlabs.iitkgp.ernet.in/rtes/exp10/index.html#
4. https://www.tutorialspoint.com/interfacing-stepper-motor-with-8051microcontroller


## XIX Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 26: Stepper Motor interfacing to 8051 for rotating anticlockwise

## I Practical Significance

Stepper motors are commonly used in a wide range of applications such as robotics, CNC machines, 3D printers, medical equipment, and automated manufacturing machinery where precise speed control and accuracy are necessary. Stepper motors are controlled by microcontrollers in areas such as computer peripherals, Business machines, process control and for making robots. This practical will help the students to develop skills to interface stepper motor to 8051 and rotate in clockwise direction at the given angles

## II Industry/Employer Expected Outcome(s)

Maintain microcontroller based systems.

## III Course Level Learning Outcome(s)

Maintain microcontroller based applications

## IV Laboratory Learning Outcome(s)

Interface stepper motor to microcontroller and rotate in anti-clockwise direction at the given angles.

## V Relevant Affective Domain related outcome(s)

1. Follow safe practices.
2. Maintain tools and equipment.
3. Follow ethical practices.

## V I Relevant Theoretical Background

Stepper motor converts electrical energy into precise mechanical motion. It rotates a specific incremental distance per step. Every discrete step of a stepper motor is measured in degree (it can be 1.8° or even smaller depending on the stepper motor type and stepping technique).

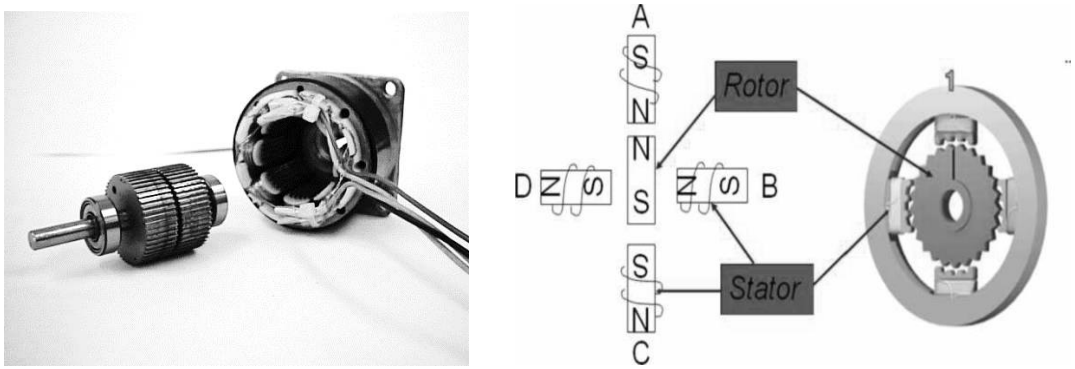


**Fig.26.1 Construction of stepper motor**

It works on the principle of electromagnetism. There is a magnetic rotor shaft of soft iron which is surrounded by the electromagnetic stators. When the stators are energized the rotor moves to align itself along with the stator (in case of a permanent magnet type stepper) or moves to have a minimum gap with the stator (in case of variable reluctance stepper). In this way the stators are energized in a sequence to rotate stepper motor

Generally, stepper motors are classified into two types according to windings as:

- Unipolar
- Bipolar

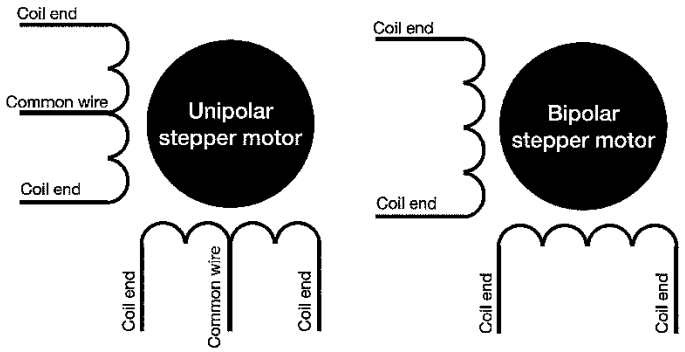


**Fig.26.2 Stepper motor types**

The unipolar stepper motors, has one winding per phase, with a center tap. It has five or six wires and four coils (actually two coils divided by center connections on each coil). The centre connections of the coils are tied together and used as the power connection. They are called unipolar stepper motors because power always comes in one pole.
The Bipolar stepper motor has four wires with no common center connection. It has two independent sets of coils.

**Step angle:**
Step angle is defined as the minimum degree of rotation with a single step.
**Number of steps per revolution =** 360° / step angle
**Steps per second =** (RPM x steps per revolution) / 60

**Table 26.1 Stepper Motor Step Angles**

| Step Angle | Steps per revolution |
|---|---|
| 0.72 | 500 |
| 1.8 | 200 |
| 2.0 | 180 |
| 2.5 | 144 |
| 5 | 72 |

**Switching Sequence of Motor**:
As the coils need to be energized for the rotation. This can be done by sending a bits sequence to one end of the coil while the other end is commonly connected. The bit sequence sent can make either one phase ON or two phase ON for a full step sequence or it can be a combination of one and two phase ON for half step sequence.

**Full Step Sequence:**

a) Wave Drive Stepping Mode (ONE PHASE ON )

**Table 26.2 Wave Drive Stepping Mode (ONE PHASE ON )**

| Clockwise | Step # | Winding A | Winding B | Winding C | Winding D | Anti-Clockwise |
|---|---|---|---|---|---|---|
| ↓ | 1 | 1 | 0 | 0 | 0 | ↑ |
| | 2 | 0 | 1 | 0 | 0 | |
| | 3 | 0 | 0 | 1 | 0 | |
| | 4 | 0 | 0 | 0 | 1 | |

**b.** Full Drive Stepping Mode (TWO PHASE ON)

**Table 26.3 Wave Drive Stepping Mode (ONE PHASE ON )**

| Clockwise | Step # | Winding A | Winding B | Winding C | Winding D | Anti-Clockwise |
|---|---|---|---|---|---|---|
| ↓ | 1 | 1 | 0 | 0 | 1 | ↑ |
| | 2 | 1 | 1 | 0 | 0 | |
| | 3 | 0 | 1 | 1 | 0 | |
| | 4 | 0 | 0 | 1 | 1 | |

**Half Step Sequence:**

- Half Drive mode:

To allow for finer resolution, all stepper motors allow an 8-step switching sequence.

**Table 26.4 8 Step Switching Sequence (ONE PHASE ON )**

| Clockwise | Step | Winding A | Winding B | Winding C | Winding D | Clockwise |
|---|---|---|---|---|---|---|
| ↓ | 1 | 1 | 0 | 0 | 1 | ↑ |
| | 2 | 1 | 0 | 0 | 0 | |
| | 3 | 1 | 1 | 0 | 0 | |
| | 4 | 0 | 1 | 0 | 0 | |
| | 5 | 0 | 1 | 1 | 0 | |
| | 6 | 0 | 0 | 1 | 0 | |
| | 7 | 0 | 0 | 1 | 1 | |
| | 8 | 0 | 0 | 0 | 1 | |

## VII Practical Circuit diagram:

a) Sample circuit diagram

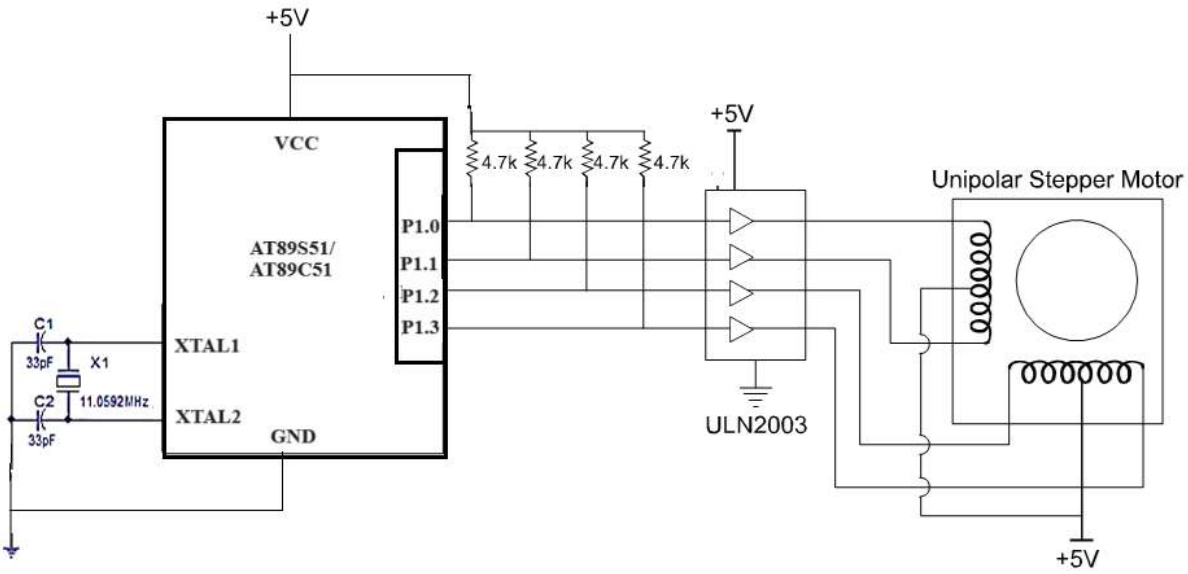


**Fig 26.3 8051 connection to stepper motor**

b) Practical setup

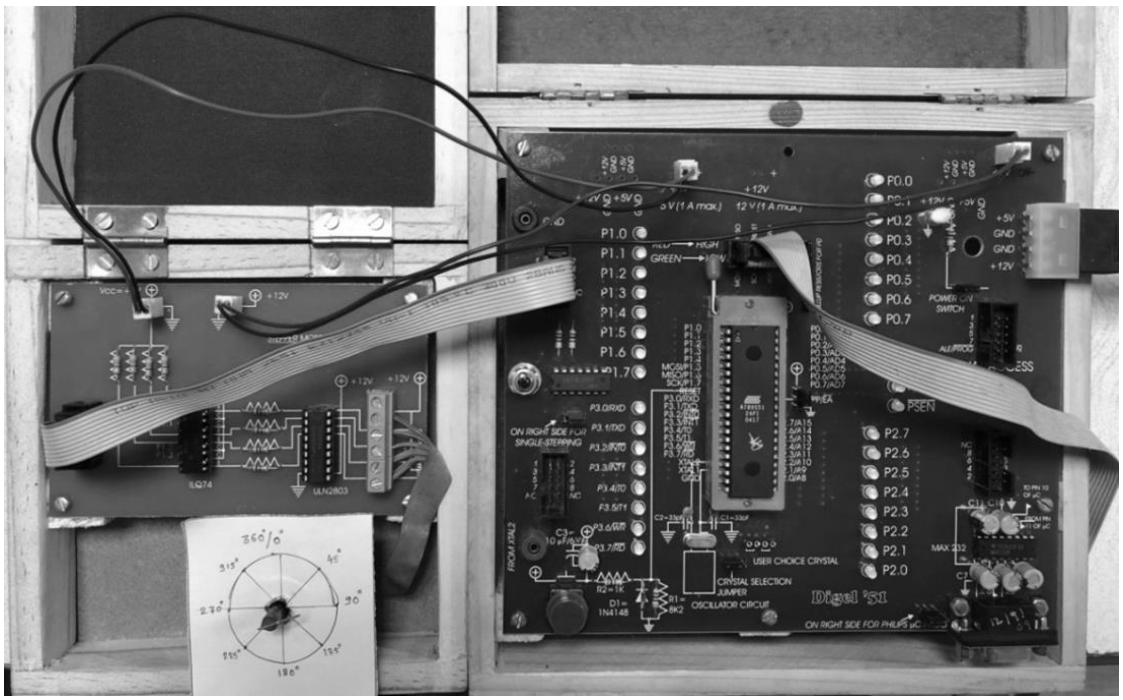

**Fig 26.4 Practical Setup**

c) Simulation diagram

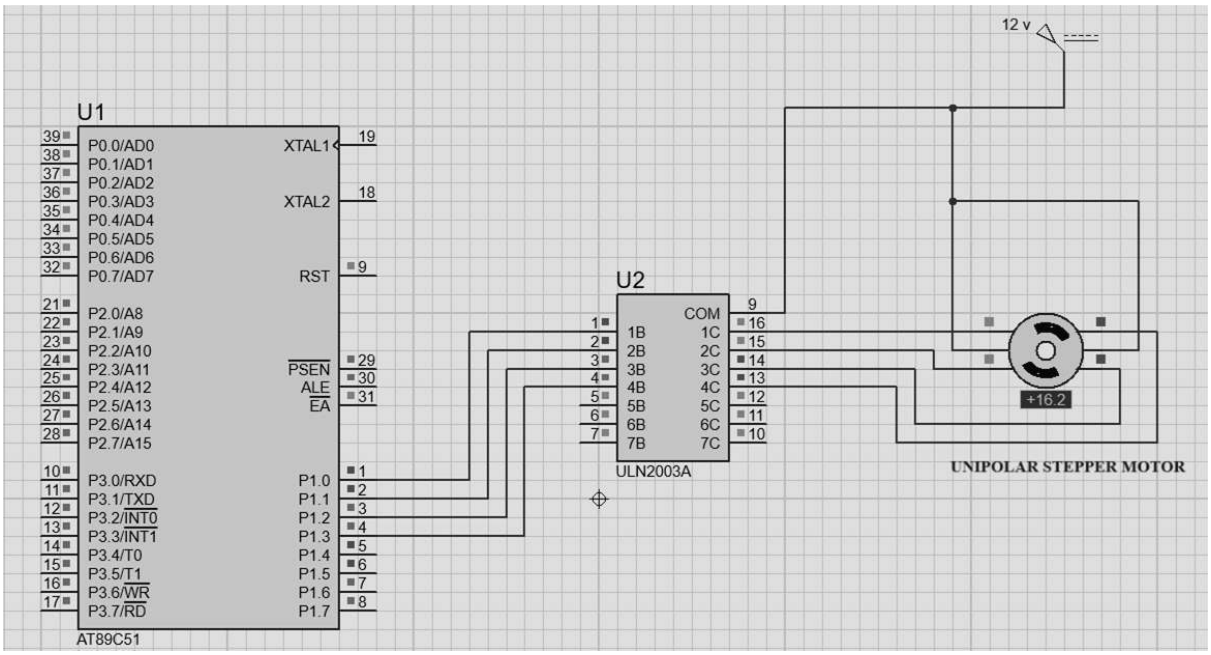


**Fig 26.5 Simulation diagram**

d) Actual circuit used in laboratory

e) Actual Experimental set up used in laboratory

## VIII Required Resources/apparatus/equipment with specifications

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Microcontroller kit | Single board system with 8K RAM, ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross C-compiler, RS-232, USB, interfacing facility with built in power supply. | 1 No. |
| 2. | Desktop PC | Loaded with open-source IDE, simulation and program downloading software. | 1 No. |
| 3. | Stepper Motor Trainer | 1.8° Step angle, 50/100 RPM Stepper motor with ULN 2003/2803 Driver. | No. |

## IX Precautions to be followed

1) Ensure proper connection before turning ON power supply to the kit.
2) Always use driver circuit while interfacing stepper motor to microcontroller.
3) Check rules / syntax of assembly language programming.

## X Procedure

1. Write algorithm for given problem.
2. Draw flowchart for the same.
3. Develop assembly program using Integrated Development Environment (IDE) or any other relevant software tool.
4. Debug program on IDE.
5. Execute program on IDE.
6. Create hex file for the above program.
7. Download hex code in EPROM/Flash memory of the microcontroller.
8. Interface stepper motor to microcontroller as per circuit diagram shown in fig 26.3
9. Observe rotation of stepper motor and record in observation Table.

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM**: Write a program to rotate stepper motor in anti-clockwise direction by$180^0$ Assume step angle of $1.8^o$ Use half step sequence

**Step 1-Algorithm**

1. Make the Port used to Interface stepper motor as an output port.
2. Set register as counter R2 =25 for 100 steps i.e.180° rotation.
3. Set register as counter R3 = 8 for half step code
4. Initialize pointer to table which is in code memory i.e. DPTR.
5. Clear accumulator.
6. Read data from code memory.
7. Send code to stepper motor.
8. Increment DPTR to access next memory location code.
9. Decrement R3 and if R3 ≠ 0, go to step 5 else go to next.
10. Decrement R2 and if R2 ≠ 0, go to step 3 else go to next.
11. Stop.

**Step 2-Flow Chart**

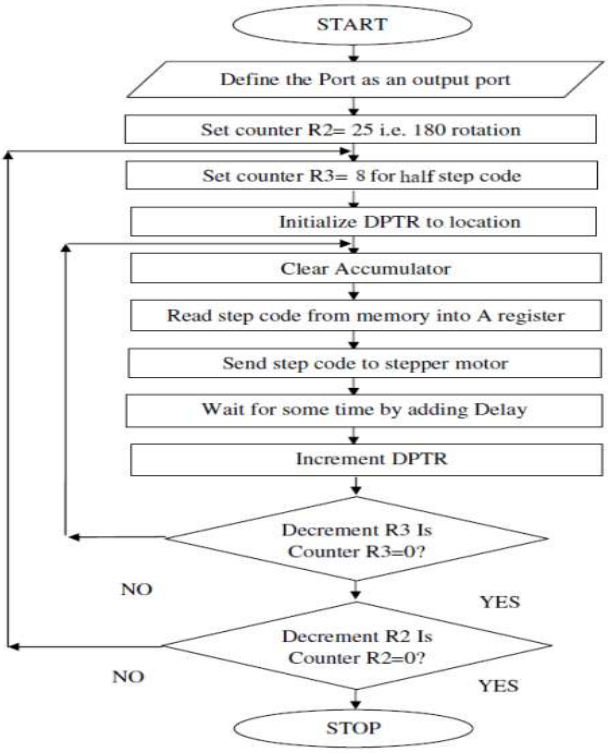


**Fig 26.6 Flowchart for stepper motor to rotate in anti-clockwise direction by $180^o$**

**Step 3-Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | |
| C:0x0000 | 759000 | | MOV P1,#00H | ;Define port P1 as output port |
| C:0x0003 | 7A19 | | MOV R2,#25 | ;Set register as counter of 25 for $180^0$ rotation |
| C:0x0005 | 7B08 | UP1: | MOV R3,#8 | ;set counter of 8 for half step code sequence |
| C:0x0007 | 900200 | | MOV DPTR,#TABLE | ;load address of program memory into Data pointer |
| C:0x000A | E4 | UP: | CLR A | ;clear accumulator |
| C:0x000B | 93 | | MOVC A,@A+DPTR | ;read step code from memory into accumulator |
| C:0x000C | F590 | | MOV P1,A | ;send step code to port |
| C:0x000E | 1117 | | ACALL DELAY | ;add delay |
| C:0x0010 | A3 | | INC DPTR | ;increment memory pointer to read next step code |
| C:0x0011 | DBF7 | | DJNZ R3,UP | ; decrement counter & jump to memory location labeled as UP if not equal to zero. |
| C:0x0013 | DAF0 | | DJNZ R2,UP1 | ; decrement counter & jump to memory location labeled as UP1 if not equal to zero. |
| C:0x0015 | 80FE | HERE: | SJMP HERE | ;wait |
| C:0x0017 | 7C64 | DELAY: | MOV R4,#100 | ;delay Subroutine |
| C:0x0019 | 7D19 | L3: | MOV R5,#25 | |
| C:0x001B | 7E19 | L2: | MOV R6,#25 | |
| C:0x001D | DEFE | L1: | DJNZ R6,L1 | |
| C:0x001F | DDFA | | DJNZ R5,L2 | |
| C:0x0021 | DCF6 | | DJNZ R4,L3 | |
| C:0x0023 | 22 | | RET | |
| | | | ORG 0050H | |
| C:0x0050 | | TABLE: | DB 01H,03H,02H, 06H, 04H, 0CH,08H, 09H, | ; Step code stored at code memory starting at location 0050H onward. |
| | | | END | |

**Problem statement for student**: Write a program to rotate stepper motor in anti-clockwise direction by $360^{0.}$ Use full step sequence. Assume step angle of $1.8^{0}$

| **Step 1-Algorithm** | **Step 2-Flowchart** |
|---|---|
| | |

**Step 3- Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
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## X I Resources used

| Sr. No. | Name of Resource | Specifications | Quantity |
|---|---|---|---|
| | | | |
| | | | |

**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……
8. ……

**XIII Observations for sample Program** (use blank sheet provided if space not sufficient)

| Steps | Step code | Port pin status (0 / 1) | | | |
|---|---|---|---|---|---|
| | | P1.3 | P1.2 | P1.1 | P1.0 |
| **Step 1** | | | | | |
| **Step 2** | | | | | |
| **Step 3** | | | | | |
| **Step 4** | | | | | |
| **Step 5** | | | | | |
| **Step 6** | | | | | |
| **Step 7** | | | | | |
| **Step 8** | | | | | |

**XIV Results (Output of the Program)**

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**XV Interpretation of Results (Give meaning of the above obtained results)**

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**XVI Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

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**XVII Practical related questions**

***Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.***

1. If a stepper motor takes 90 steps to make one complete revolution, calculate the step angle for this motor.
2. Write specifications of stepper motor used in the lab.

**[Space for Answers]**

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## XVIII References/Suggestions for further reading

1. https://www.monolithicpower.com/learning/resources/stepper-motors-basics-types-uses
2. https://www.portescap.com/en/products/stepper-motor-control
3. http://vlabs.iitkgp.ernet.in/rtes/exp10/index.html#
4. https://www.tutorialspoint.com/interfacing-stepper-motor-with-8051microcontroller

## XIX Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 27: Water Level Controller using 8051

## I Practical Significance

The control of water levels is critical in various environmental and industrial contexts. Water level control is essential for flood control, water supply management, ecosystem stability, energy production, climate resilience, infrastructure protection, and navigational safety. This practical will help the students to develop water level controller using 8051 and display the status of Water tank on LCD.

## II Industry/Employer expected outcome(s)

Maintain microcontroller-based systems.

## III Course Level Learning Outcome(s)

Maintain microcontroller-based applications.

## IV Laboratory Learning Outcome(s)

Design water level controller using any suitable open-source simulation software to detect and control the water level in a tank.

## V Relevant Affective domain related Outcome(s)

Follow ethical practices.

## VI Relevant Theoretical Background

Sensors are crucial for measuring water levels accurately. Ultrasonic, capacitive, and float sensors provide the necessary data for system adjustments. Advanced control systems utilize automation and robotics to operate gates, pumps, and valves, ensuring optimal water levels without human intervention. Thus, the water level controllers integrate control theory, sensor technology, hydraulic modeling, automation, mechanical engineering, communication technologies, and feedback mechanisms to maintain desired water levels efficiently.

Water level control system utilizes sensors to determine the water level in the tank which provides the real time value to the microcontroller 8051 which compares with the set value and takes decision whether to turn off the motor or keep it on which controls the water level in the tank and also displays the status of water level on LCD display.

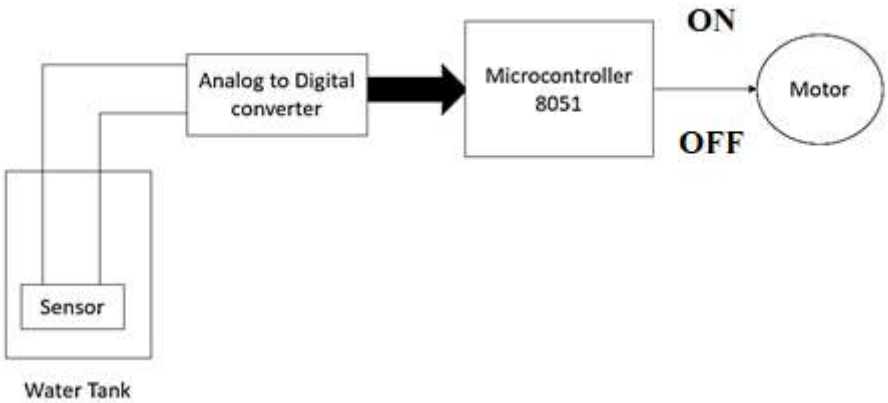


**Fig 27.1 Water Level Controller basic block diagram**

## VII Actual Circuit Diagram used in laboratory

### a) Simulation Diagram:

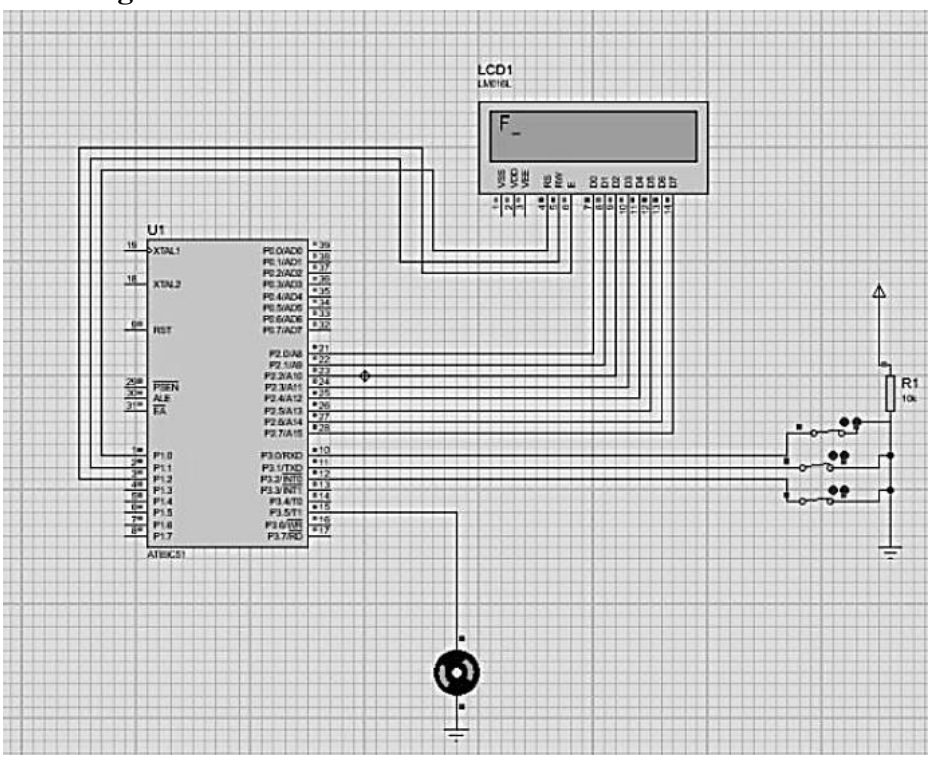


**Fig 27.1: Simulation Diagram**

### b) Simulation Diagram used:

## VIII Resources Required

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1 | Microcontroller kit | Single board systems with 8K RAM, ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross c-compiler, RS-232, USB, interfacing facility with built in power supply. | 1 No. |
| 2 | Desktop PC | Loaded with open-source IDE, simulation and program downloading software | 1 No. |
| 3 | Resistor | 10 Kilo Ohms | 1No. |
| 4. | Liquid Crystal Display | 16 x 2 LCD | 1 No. |
| 5. | Simple DC Motor | Nominal Voltage 12V, Load Resistance 12 Ohms | 1No. |

## IX Precautions to be Followed

1. Check rules / syntax of assembly programming.
2. Operate DAC chip as per specifications given in the datasheet otherwise damage may occur to the device.

## X Procedure

**Write Program**

1. Start Keil by double clicking on Keil icon.
2. Create a new project.
3. Select device for Target.
4. Double click on ATMEL and select AT89C51.
5. Type the program in text editor and save as filename.asm extension.

**Compile the Program**

6. Right click on source group and build the target.
7. Check for any errors in the output window and remove if any.

**Run, Debug the Program**

8. Click on Debug and start simulation and start/stop debug session.
9. Run the program step by step.
10. Observe the output on the project window.
11. Note the values of the result of various operations in the observation table.

## E-Waste Management

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM 1**: Write a program to detect and control the water level in tank and display the status on LCD.

**STEP1- Algorithm**

1. Configure the Port 0 and Port 2 as an output port.
2. Configure Port 3 pin 5 as output port pin to make the motor ON and OFF.
3. Configure Port 3 pin 3.0 to pin 3.3 as input pins to sense the status of Water level in tank.
4. Determine the water level by reading status of sensors connected.
5. If water tank is full then turn off the motor and display full on LCD.
6. Else keep the motor ON and display the status on LCD.
7. Repeat the process by going back to step 4.

**Step 2-Flow Chart**

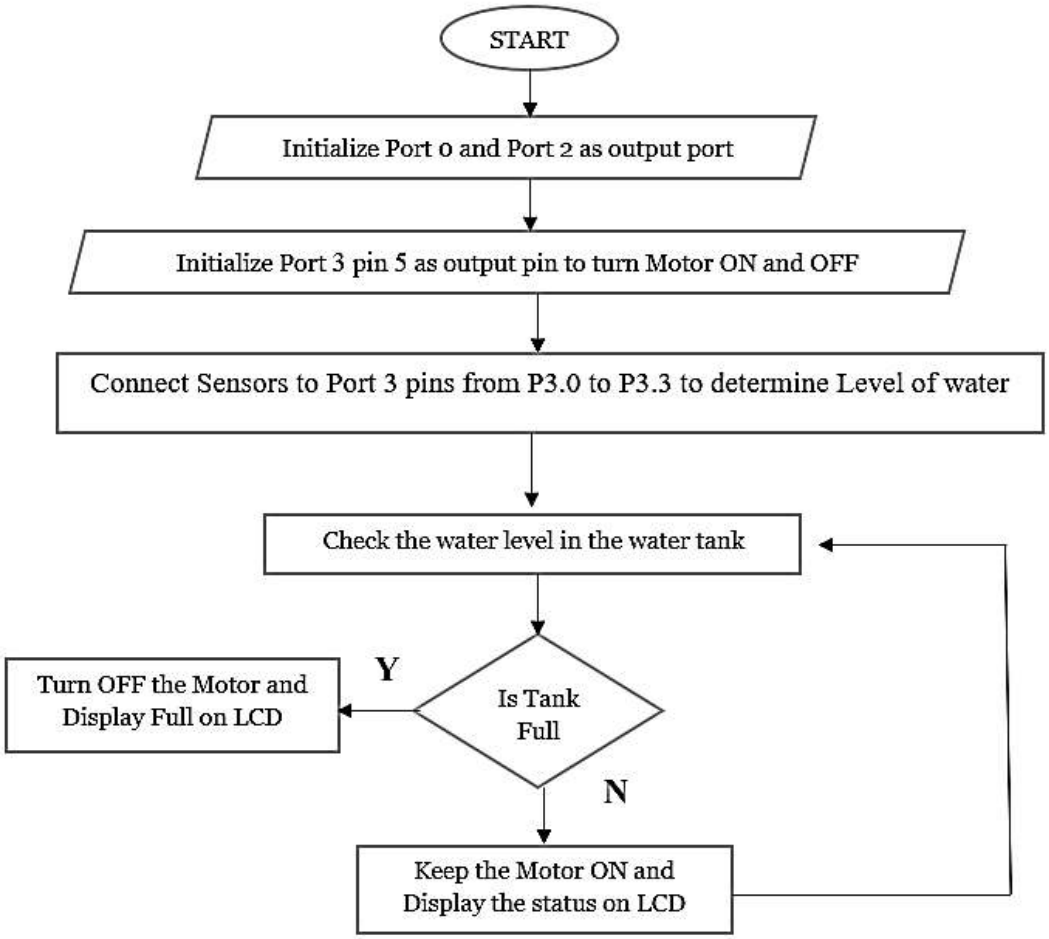


**Fig 27.2 Flowchart for Water Level Controller**

**Step 3-Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | RS BIT P1.0 | |
| | | | RW BIT P1.1 | |
| | | | E BIT P1.2 | |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ORG 0000H | |
| C:0X0000 | 30B00E | CHECK: | JNB P3.0, LCDDISPLAY | Check the status of water level |
| C:0X0003 | 30B10B | | JNB P3.1, LCDDISPLAY | Check the status of water level |
| C:0X0006 | C285 | | CLR P3.5 | |
| C:0X0008 | 30B206 | | JNB P3.2, LCD DISPLAY | Check the status of water level |
| C:0X000B | D2B5 | | SETB P3.5 | |
| C:0X000D | 1111 | | ACALL LCD DISPLAY | |
| C:0X000F | 80EF | | SJMP CHECK | |
| C:0X0011 | C290 | LCDDISPLAY: | CLR RS | |
| C:0X0013 | C291 | | CLR RW | |
| C:0X0015 | C292 | | CLR E | |
| C:0X0017 | 7438 | | MOV A, #38H | Initialize LCD |
| C:0X0019 | 1162 | | ACALL LCDCMD | |
| C:0X001B | 117C | | ACALL DELAY | |
| C:0X001D | 740E | | MOV A, #0EH | |
| C:0X001F | 1162 | | ACALL LCDCMD | |
| C:0X0021 | 117C | | ACALL DELAY | |
| C:0X0023 | 7406 | | MOV A, #06H | |
| C:0X0025 | 1162 | | ACALL LCDCMD | |
| C:0X0027 | 117C | | ACALL DELAY | |
| C:0X0029 | 7401 | | MOV A, #01H | |
| C:0X002B | 1162 | | ACALL LCDCMD | |
| C:0X002D | 117C | | ACALL DELAY | |
| C:0X002F | 7480 | | MOV A, #80H | |
| C:0X0031 | 1162 | | ACALL LCDCMD | |
| C:0X0033 | 117C | | ACALL DELAY | |
| C:0X0035 | 30B008 | | JNB P3.0, F_DISPLAY | |
| C:0X0038 | 30B10F | | JNB P3.1, H_DISPLAY | |
| C:0X003B | 30B214 | | JNB P3.2, Q_DISPLAY | |
| C:0X003E | 115A | | ACALL E_DISPLAY | |
| C:0X0040 | 7446 | F_DISPLAY: | MOV A, # “F” | Display Tank Full |
| C:0X0042 | 1164 | | ACALL LCDDATA | Call Subroutine for LCD display |
| C:0X0044 | 117C | | ACALL DELAY | Call Delay |
| C:0X0046 | C2B5 | | CLR P3.5 | |
| C:0X0048 | 80B6 | | SJMP CHECK | |
| C:0X004A | 7448 | H_DISPLAY: | MOV A, # “H” | Display Tank Half Full |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0X004C | 116F | | ACALL LCDDATA | Call Subroutine for LCD display |
| C:0X004E | 117C | | ACALL DELAY | Call Delay |
| C:0X0050 | 80AE | | SJMP CHECK | |
| C:0X0052 | 7451 | Q_DISPLAY: | MOV A, # “Q” | Display Tank Quarter Full |
| C:0X0054 | 116F | | ACALL LCDDATA | Call Subroutine for LCD display |
| C:0X0056 | 117C | | ACALL DELAY | Call Delay |
| C:0X0058 | 80A6 | | SJMP CHECK | |
| C:0X005A | 7445 | E_DISPLAY: | MOV A, # “E” | Display Tank Empty |
| C:0X005C | 116F | | ACALL LCDDATA | Call Subroutine for LCD display |
| C:0X005E | 117C | | ACALL DELAY | Call Delay |
| C:0X0060 | 809E | | SJMP CHECK | |
| C:0X0062 | C290 | LCDCMD: | CLR RS | Subroutine for LCD Commands |
| C:0X0064 | C291 | | CLR RW | |
| C:0X0066 | F5A0 | | MOV P2, A | |
| C:0X0068 | D292 | | SETB E | |
| C:0X006A | 117C | | ACALL DELAY | |
| C:0X006C | C292 | | CLR E | |
| C:0X006E | 22 | | RET | |
| C:0X006F | D290 | LCDDATA: | SETB RS | Subroutine for LCD data display |
| C:0X0071 | C291 | | CLR RW | |
| C:0X0073 | F5A0 | | MOV P2, A | |
| C:0X0075 | D292 | | SETB E | |
| C:0X0077 | 117C | | ACALL DELAY | |
| C:0X0079 | C292 | | CLR E | |
| C:0X007B | 22 | | RET | |
| C:0X007C | A8FF | DELAY: | MOV RO, #FFH | Delay Subroutine |
| C:0X007E | 79FF | BACK1: | MOV R1, #FFH | |
| C:0X0080 | D9FE | HERE: | DJNZ R1, HERE | |
| C:0X0082 | D8FA | | DJNZ R0, BACK1 | |
| C:0X0084 | 22 | | RET | |
| | | | END | |

**XI Resources Used:**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |

**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

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**XIII Observations for sample program**

| Switch | Switch Status | LCD Display |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |

**XIV Results** (Output of the Program)

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**XV Interpretation of Results (**Give meaning of the above obtained results)

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**XVI Conclusions and Recommendation (**Actions/decisions to be taken based on the interpretation of results).

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**XVII Practical Related Questions**

***Note: Below given are few sample questions for reference. Teacher must design more such questions so as to ensure the achievement of identified CO***

**a)** List different types of sensors used to determine the liquid level.

**b)** List the sensors used in determining the level of corrosive liquid.

**c)** Give the principle of operation of any one liquid level sensor.

**d)** Justify the need of Analog to Digital [ADC] converter in designing water level controller.

**[Space for Answers]**

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**XVIII References / Suggestions for further reading**

1. https://www.electronicshub.org/water-level-controller-using-8051-microcontroller/
2. https://www.circuitstoday.com/water-level-controller-using-8051
3. https://www.electronicsforu.com/electronics-projects/hardware-diy/water-level-controller-cum-motor-protector

**XIX Assessment Scheme**

The given performance indicators should serve as a guideline for assessment regarding process and product related marks:

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40% (10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 % (25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |

# Practical No. 28: Temperature Sensor interfacing to detect and measure temperature

## I Practical Significance

The measurement of temperature by using appropriate sensors and controllers is not only important in environmental or weather monitoring but also crucial for many industrial processes. Usually, a temperature sensor converts the temperature into an equivalent voltage output. IC LM35 is such a sensor. This practical will help the students to develop skills to interface temperature sensor to the microcontroller, read temperature and display its value on LCD.

## II Industry/Employer Expected Outcome(s)

Maintain microcontroller based systems.

## III Course Level Learning Outcome(s)

Maintain microcontroller based applications

## IV Laboratory Learning Outcome(s)

Interface temperature sensor LM35 to 8051 to read temperature, convert it to decimal and send the value to Port 0 with some delay

## V Relevant Affective Domain related outcome(s)

1. Follow safe practices.
2. Maintain tools and equipment.
3. Follow ethical practices.

## V I Relevant Theoretical Background


**Fig.28.1 Temperature monitoring system**

### LM35 Temperature Sensor:

The LM35 series are precision integrated-circuit analog temperature sensor with an output voltage linearly proportional to the Centigrade temperature around it. It is a small and cheap IC which can be used to measure temperature anywhere between -55°C to 150°C. The LM35 comes already calibrated hence requires no external calibration.

**LM35 Features:**

1. Calibrated Directly in Celsius (Centigrade)
2. Operates From 4 V to 30 V. Typically 5V.
3. Can measure temperature ranging from -55°C to 150°C
4. Output voltage is directly proportional (Linear) to temperature
5. ±0.5°C Accuracy

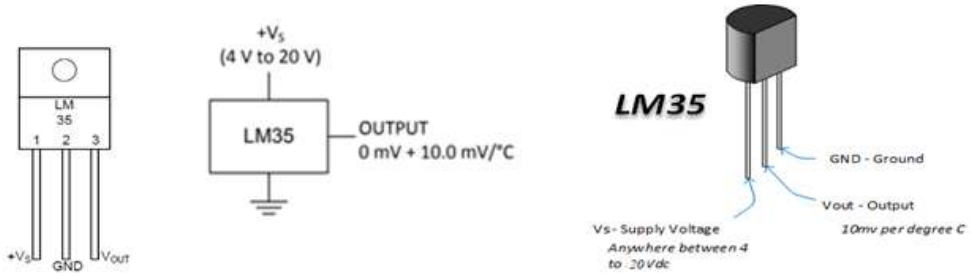


**Fig.28.2 Pin Diagram of LM35**

**Pin description:**

| Pin Number | Pin Name | Description |
|---|---|---|
| 1 | Vs | Input voltage is +5V for typical applications |
| 2 | Analog Out | There will be increase in 10mV for raise of every 1°C. |
| 3 | Ground | Connected to ground of circuit |

**Temperature to voltage conversion:**

$V_{OUT}$ = 10mV / ºC x T
T = $V_{OUT}$ / 10 mV(milliVolt)
Where Vout = LM35 output voltage, T = Temperature sensed in centigrade
This means at 100°C, Vout = 10 mV x 100 = 1000 mV = 1Volt

**ADC0808:**

An analog-to-digital converter, or simply ADC, is a semiconductor device that is used to convert an analog signal into a digital code. An analog signal is a signal that may assume any value within a continuous range. Examples of analog signals commonly encountered every day are sound, light, temperature, and pressure, all of which may be represented electrically by an analog voltage or current.

| **Specifications ADC0808 Chip** | **ADC0808 Analog signal selection:** |
|---|---|
| 1. Resolution -8 Bits<br>2. Input Channels- 8<br>3. Single Supply- 5VDC<br>4. Low Power- 15mW<br>5. Conversion Time -100µs<br>6. The clock frequency range of ADC is 10 KHz to 1280 KHz.<br>7. Typically 680 kHz used.<br>8. Low power consumption | Analog Channel C B A<br>IN0 0 0 0<br>IN1 0 0 1<br>IN2 0 1 0<br>IN3 0 1 1<br>IN4 1 0 0<br>IN5 1 1 1<br>IN6 1 1 0<br>IN7 1 1 1 |

**ADC0808 Pin diagram:**

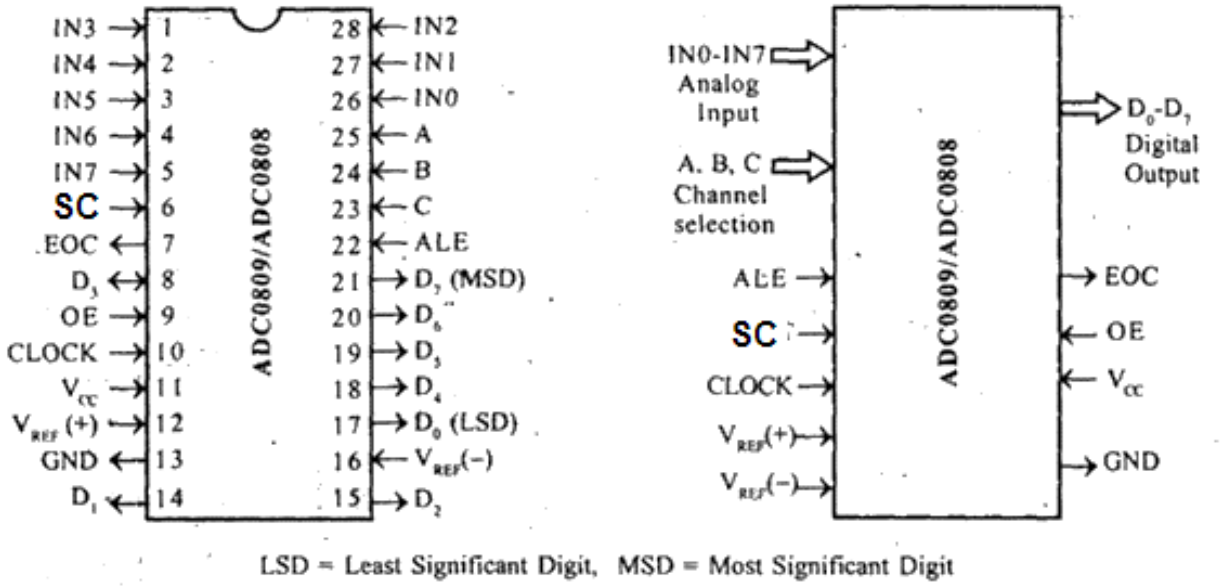


**Fig 28.3 ADC 0808 Pin diagram**

**Table 28. 1: ADC 0808 Pin functions**

| Signals | Description |
|---|---|
| IN0-IN7 | Eight single ended analog input to ADC. |
| A, B, C | 3-bit binary input to select one of the eight analog signals for conversion at any one time. |
| ALE | Address latch enable. Used to latch the 3-bit address input to an internal latch. |
| SC | Start of conversion pulse input. To start ADC process this signal should be asserted **high** and then **low**. This signal should remain **high** for atleast 100ns. |
| CLOCK | Clock input and the frequency of clock can be in the range of 10 kHz to 1280 kHz. Typical clock input is 640 kHz. |
| $V_{REF}(+), V_{REF}(-)$ | Reference voltage input. The positive reference voltage can be less than or equal to $V_{cc}$ and the negative reference voltage can be greater than or equal to ground. |
| $D_0$-$D_7$ | The 8-bit digital output. The reference voltages will decide the mapping of analog input to digital data. |
| EOC | End of conversion. This signal is asserted **high** by the ADC to indicate the end of conversion process and it can be used as interrupt signal to processor |
| OE | Output buffer Enable. This signal is used to read the digital data from output buffer after a valid EOC. |
| $V_{cc}$ | Power supply, +5V |
| GND | Power supply ground, 0 V |

## VII Practical Circuit diagram:

a) Sample circuit diagram

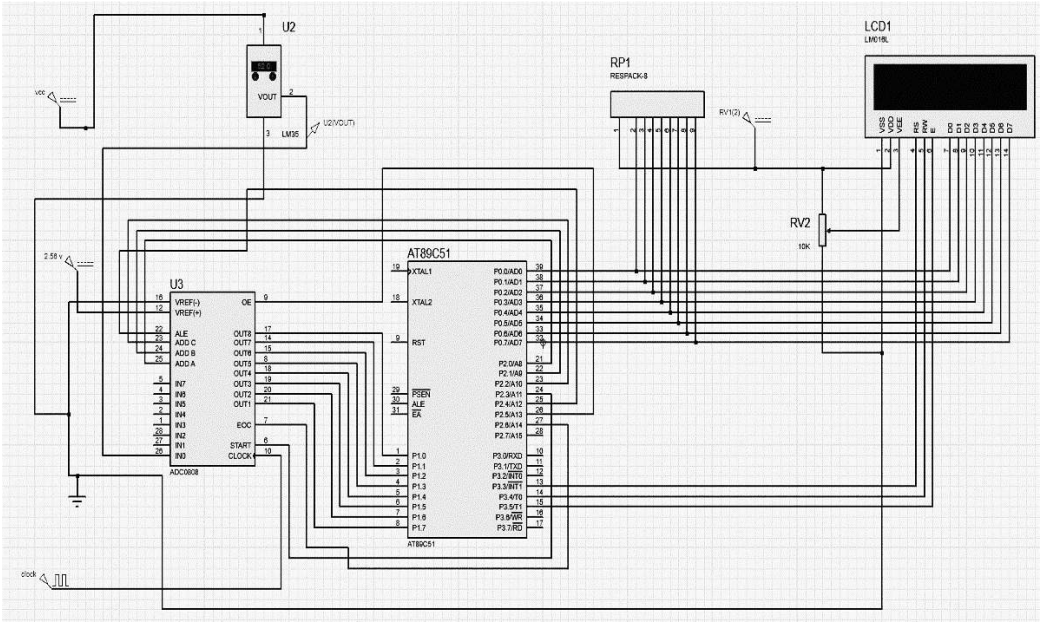


**Fig 28.4 8051 connection to ADC and LM35**

b) Simulation diagram

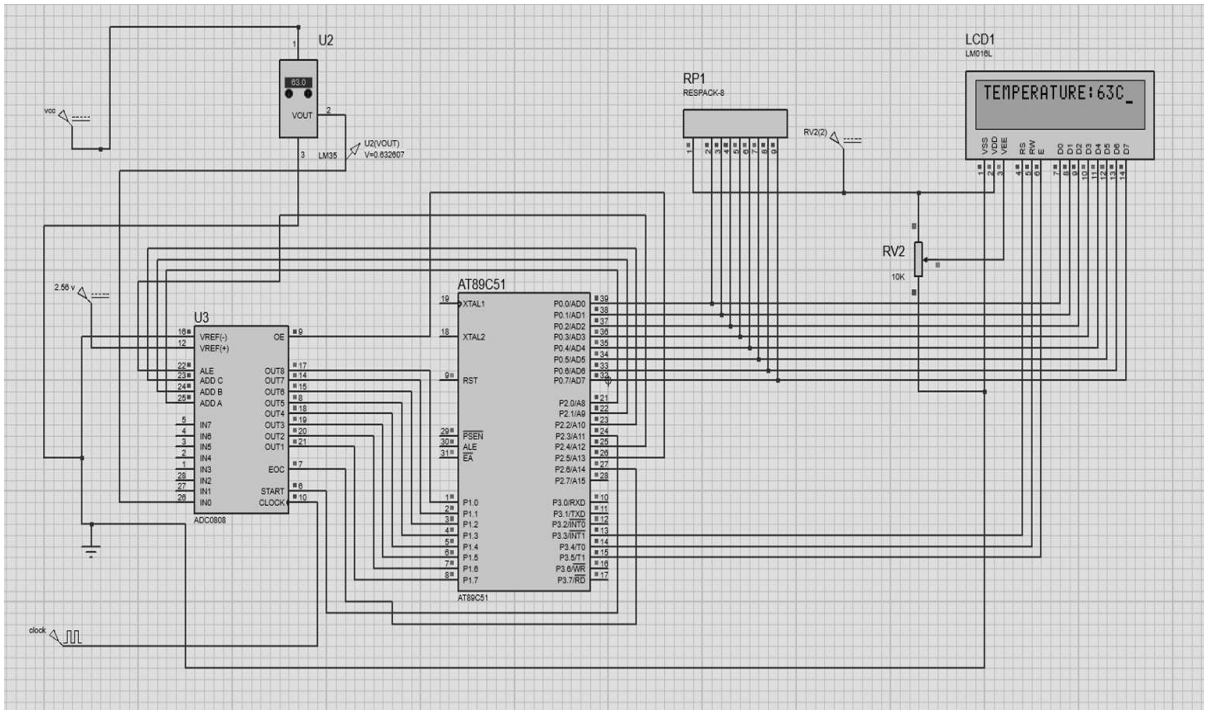


**Fig 28.5 Simulation diagram**

c) Actual circuit used in laboratory

## VIII Required Resources/apparatus/equipment with specifications

| Sr. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | Microcontroller kit | Single board system with 8K RAM,ROM memory with battery backup,16X4,16X2LCD display, PC keyboard interfacing facility, Hex keypad facility, single user cross C-compiler,RS-232,USB, interfacing facility with built in power supply. | 1 No. |
| 2. | Desktop PC | Loaded with open source IDE, simulation and program downloading software. | 1 No. |
| 3. | ADC (0808) trainer board | Suitable to interface 8051 board. | 1 No. |
| 4. | LM 35 Temperature sensor | Suitable to interface ADC 0808 | 1 No. |

## IX Precautions to be followed

1) Care should be taken while operating LM 35 as it is rated to operate over −55°C to 150°C temperature range
2) Refer datasheet for to provide clock frequency to ADC 0808 chip.
3) Care must be taken while taking observations during power up.
4) Check rules / syntax of assembly language programming.

## X Procedure

1. Write algorithm for given problem.
2. Draw flowchart for the same.
3. Develop assembly program using Integrated Development Environment (IDE) or any other relevant software tool.
4. Debug program on IDE.
5. Execute program on IDE.
6. Create hex file for the above program.
7. Download hex code in EPROM/Flash memory of the microcontroller.
8. Interface LM 35 to ADC 0808 IC and connect ADC output and LCD display to the microcontroller as per circuit diagram shown in fig 28.4
9. Vary temperature of LM 35 and observe ADC output on LCD display.

**E-Waste Management**

1. Identify pin configuration of the ICs and test the ICs on the IC tester.
2. If the IC is faulty then keep it in the proper e-waste bin.
3. If the IC is in OK condition, then mount it on breadboard or the trainer kit.
4. Utilize software-based simulations for training, decreasing the reliance on physical trainer kits and subsequently reducing e-waste

**SAMPLE PROGRAM**: Write a program to read the temperature, convert it to decimal and display on LCD

.**Step 1-Algorithm**

1. Define control signals RS, RW and EN for LCD and initialize LCD by sending commands.
2. Select an analog channel by providing bits to A, B, and C addresses according to the analog signal selection table.
3. Activate the ALE (address latch enable) pin.
4. Activate SC (start conversion) to initiate conversion.
5. Monitor EOC (end of conversion) to see whether conversion is finished. H-to-L output indicates that the data is converted and is ready to be picked up. If we do not use EOC, we can read the converted digital data after a brief time delay. The delay size depends on the speed of the external clock we connect to the CLK pin.
6. Activate OE (output enable) to read data out of the ADC chip.

*Note:* In ADC0808 that there is no self-clocking and the clock must be provided from an external source to the CLK pin. Although the speed of conversion depends on the frequency of the clock connected to the CLK pin, it cannot be faster than 100 microseconds.

**Step 2-Flow Chart**

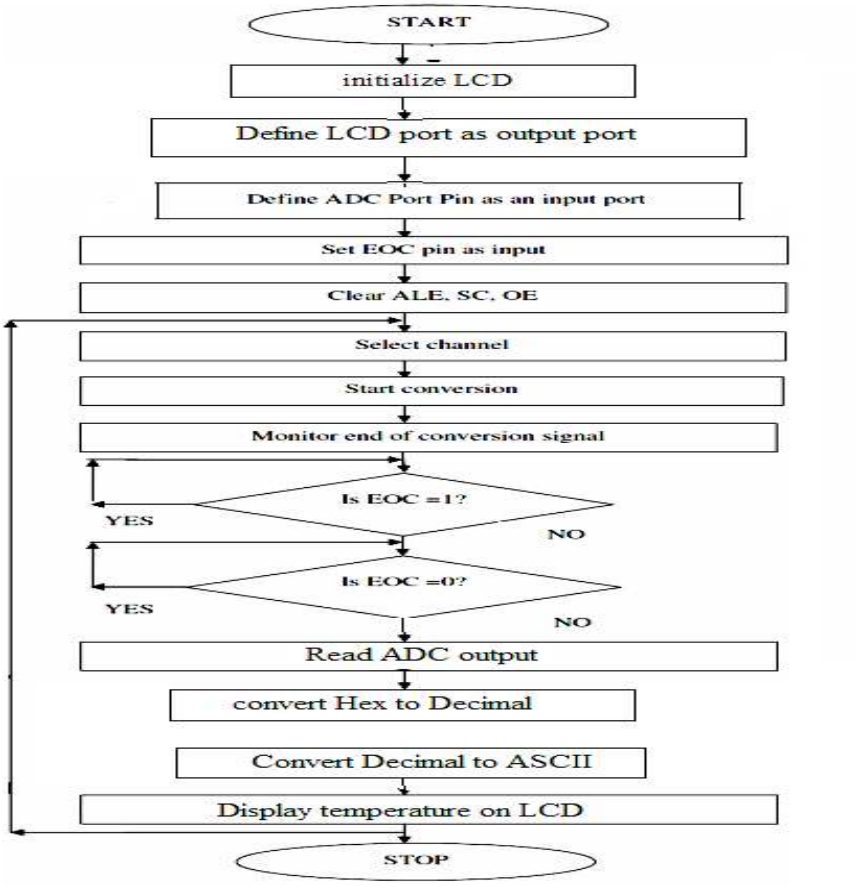


**Fig 28.6 Flowchart for temperature measurement**

**Step 3-Assembly Language Program**

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | RS EQU P3.3 | |
| | | | RW EQU P3.4 | |
| | | | EN EQU P3.5 | |
| | | | ALE BIT P2.0 | |
| | | | SC BIT P2.1 | |
| | | | EOC BIT P2.2 | |
| | | | OE BIT P2.3 | |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| | | | ADDR_A BIT P2.4 | |
| | | | ADDR_B BIT P2.5 | |
| | | | ADDR_C BIT P2.6 | |
| | | | | |
| | | | ORG 0000H | |
| C:0x0000 | 758000 | | MOV P0,#00H | ;make P0 as output |
| C:0x0003 | 1163 | BACK: | ACALL LCD | |
| C:0x0005 | 7590FF | | MOV P1,#0FFH | ;make P1 as input |
| C:0x0008 | D2A6 | | SETB EOC | ;make EOC an input |
| C:0x000A | C2A4 | | CLR ALE | ;clear ALE |
| C:0x000C | C2A3 | | CLR SC | ;clear WR |
| C:0x000E | C2A5 | | CLR OE | ;clear RD |
| C:0x0010 | C2A2 | | CLR ADDR_C | ;C=0 |
| C:0x0012 | C2A1 | | CLR ADDR_B | ;B=0 |
| C:0x0014 | C2A0 | | CLR ADDR_A | ;A=0 (select channel 0) |
| C:0x0016 | D2A4 | | SETB ALE | ;latch address |
| C:0x0018 | 1131 | | ACALL DELAY | |
| C:0x001A | D2A3 | | SETB SC | ;start conversion |
| C:0x001C | 1131 | | ACALL DELAY | |
| C:0x001E | C2A4 | | CLR ALE | |
| C:0x0020 | C2A3 | | CLR SC | |
| C:0x0022 | 20A6FD | HERE: | JB EOC,HERE | ;wait |
| C:0x0025 | 30A6FD | HERE1: | JNB EOC,HERE1 | |
| C:0x0028 | D2A5 | | SETB OE | |
| C:0x002A | 1131 | | ACALL DELAY | |
| C:0x002C | E590 | | MOV A,P1 | ;Read ADC data |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x002E | C2A5 | | CLR OE | |
| C:0x0030 | 1143 | | ACALL CONV | ;call hex to ASCII |
| C:0x0032 | 1158 | | ACALL WRITETMP | ; display temperature |
| C:0x0034 | 80CD | | SJMP BACK | |
| C:0x0036 | 7B19 | DELAY: | MOV R3,#25 | ;Delay Subroutine |
| C:0x0038 | 7C64 | L3: | MOV R4,#100 | |
| C:0x003A | 7D64 | L2: | MOV R5,#100 | |
| C:0x003C | DDFE | L1: | DJNZ R5,L1 | |
| C:0x003E | DCFA | | DJNZ R4,L2 | |
| C:0x0040 | DBF6 | | DJNZ R3,L3 | |
| C:0x0042 | 22 | | RET | |
| C:0x0043 | 75F00A | CONV: | MOV B,#10 | ; HEX to ASCII conversion |
| C:0x0046 | 84 | | DIV AB | |
| C:0x0047 | AFF0 | | MOV R7,B | |
| C:0x0049 | 75F00A | | MOV B,#10 | |
| C:0x004C | 84 | | DIV AB | |
| C:0x004D | AEF0 | | MOV R6,B | |
| C:0x004F | EE | | MOV A,R6 | |
| C:0x0050 | 2430 | | ADD A,#30H | |
| C:0x0052 | FE | | MOV R6,A | |
| C:0x0053 | EF | | MOV A,R7 | |
| C:0x0054 | 2430 | | ADD A,#30H | |
| C:0x0056 | FF | | MOV R7,A | |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x0057 | 22 | | RET | |
| C:0x0058 | EE | | MOV A,R6 | |
| C:0x0059 | 119E | | ACALL LCDWRITE | |
| C:0x005B | EF | | MOV A,R7 | |
| C:0x005C | 119E | | ACALL LCDWRITE | |
| C:0x005E | 7443 | | MOV A,#'C' | |
| C:0x0060 | 119E | | ACALL LCDWRITE | |
| C:0x0062 | 22 | | RET | |
| C:0x0063 | 117C | LCD: | ACALL LCD_INIT | |
| C:0x0065 | 9000AB | | MOV DPTR, #MSG | |
| C:0x0068 | 7A0C | | MOV R2, #12 | |
| C:0x006A | E4 | | UP:CLR A | |
| C:0x006B | 93 | | MOVC A,@A+DPTR | |
| C:0x006C | 119E | | ACALL LCDWRITE | |
| C:0x006E | A3 | | INC DPTR | |
| C:0x006F | DAF9 | | DJNZ R2, UP | |
| C:0x0071 | 22 | | RET | |
| C:0x0072 | 7438 | LCD_INIT: | MOV A, #38H | ;LCD initialization |
| C:0x0074 | 1191 | | ACALL CMD | |
| C:0x0076 | 740E | | MOV A, #0EH | |
| C:0x0078 | 1191 | | ACALL CMD | |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x007A | 7401 | | MOV A, #01H | |
| C:0x007C | 1191 | | ACALL CMD | |
| C:0x007E | 7406 | | MOV A, #06H | |
| C:0x0080 | 1191 | | ACALL CMD | |
| C:0x0082 | 7480 | | MOV A, #80H | |
| C:0x0084 | 1191 | | ACALL CMD | |
| C:0x0086 | 22 | | RET | |
| C:0x0087 | F580 | CMD: | MOV P0, A | ;LCD Command subroutine |
| C:0x0089 | C2B3 | | CLR RS | |
| C:0x008B | C2B4 | | CLR RW | |
| C:0x008D | D2B5 | | SETB EN | |
| C:0x008F | C2B5 | | CLR EN | |
| C:0x0091 | 1136 | | ACALL DELAY | |
| C:0x0093 | 22 | | RET | |
| C:0x0094 | F580 | LCDWRITE: | MOV P0, A | ;LCD data subroutine |
| C:0x0096 | D2B3 | | SETB RS | |
| C:0x0098 | C2B4 | | CLR RW | |
| C:0x009A | D2B5 | | SETB EN | |
| C:0x009C | C2B5 | | CLR EN | |
| C:0x009E | 1136 | | ACALL DELAY | |

| Memory Address | Hex Code | Label | Mnemonics | Comments |
|---|---|---|---|---|
| C:0x00A0 | 22 | | RET | |
| | | MSG: | DB "TEMPERATURE:" | |
| | | | END | |

**XI Resources Used**

| S. No. | Instrument /Components | Specification | Quantity |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |

**XII Actual Procedure Followed** (use blank sheet provided if space not sufficient)

1. ……
2. ……
3. ……
4. ……
5. ……
6. ……
7. ……

**XIII Observations for sample Program** (use blank sheet provided if space not sufficient)

| ADC input Voltage | Temperature displayed |
|---|---|
| | |
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| | |

**XIV Results (Output of the Program)**

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**XV Interpretation of Results (Give meaning of the above obtained results)**

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**XVI Conclusions and Recommendation** (Actions/decisions to be taken based on the interpretation of results).

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**XVII Practical related questions**

***Note: Below given are few sample questions for reference. Teacher must design more suchquestions so as to ensure the achievement of identifies CO.***

1. If output voltage of LM 35 sensor is 0.5V, then determine the Temperature detected.
2. If Vref pin is connected to 2.56V then calculate the step size of ADC0808.

**[Space for Answers]**

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## XVIII References/Suggestions for further reading


1. https://www.ti.com/product/LM35
2. https://bravelearn.com/interface-lm35-temperature-sensor-with-8051-at89c51/
3. https://www.electronicshub.org/digital-temperature-sensor-circuit/
4. https://www.youtube.com/watch?v=S5IBc_epa1A
5. https://circuitdigest.com/microcontroller-projects/interfacing-adc0808-with-8051-microcontroller

## XIX Assessment Scheme

| Performance indicators | | Weightage |
|---|---|---|
| **Process related: 15 Marks** | | **60%(15)** |
| 1 | Use of IDE tools for programming | 20% |
| 2 | Coding and Debugging ability | 30% |
| 3 | Follow ethical practices. | 10% |
| **Product related: 10 Marks** | | **40%(10)** |
| 4 | Correctness of algorithm/ Flow chart | 20% |
| 5 | Relevance of output of the problem definition | 15% |
| 6 | Timely Submission of report, Answer to sample questions | 05% |
| | **Total** | **100 %(25)** |

| Marks Obtained | | | Dated signature of Teacher |
|---|---|---|---|
| **Process Related (15)** | **Product Related (10)** | **Total (25)** | |
| | | | |