LCD and Hex keypad interfaced 8051 based 2-digit calculator using Assembly Language Program

Submitted by

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COOCHBEHAR GOVERNMENT ENGINEERING COLLEGE

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District: Cooch Behar, West Bengal

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We have no appropriate words to express sincere thanks to our family members for their continuous support and encouragement.

CONTENTS

INTRODUCTION

Our Project of this course in this semester is LCD and Hex-Keypad Interfaced 8051 microcontroller based 2-digit calculator using Assembly language program. In this project we get to simulate a 2-digit calculator which perform basic calculations like addition, subtraction, division and multiplication of 2 digits. Here we have use Edsim51 simulator to create our assembly code and run it successfully.

This simulator is equipped with a Hitachi HD44780U LCD Module. There is also 3x4 keypad present in this simulator. At first, we have interfaced the LCD Module present with the keypad with our keypad interfacing code. Then we have written the code for the basic of the calculator. Accordingly, this project aims to develop the source code based on assembly language program. This Edsim51 simulator is a perfect go-through example to understand the working module 8051

microcontroller and hence has been quite helpful for this project.

COMPONENTS USED

The various components used in this project are as follows:

A) Edsim51
B) 8051 MCU – AT89C52
C) HITACHI HD44780U LCD module
D) Matrix Keypad (4x3)
E) Push Back Switch
F) LM7805
G) Crystal
H) 2 Capacitors
I) 9V Battery

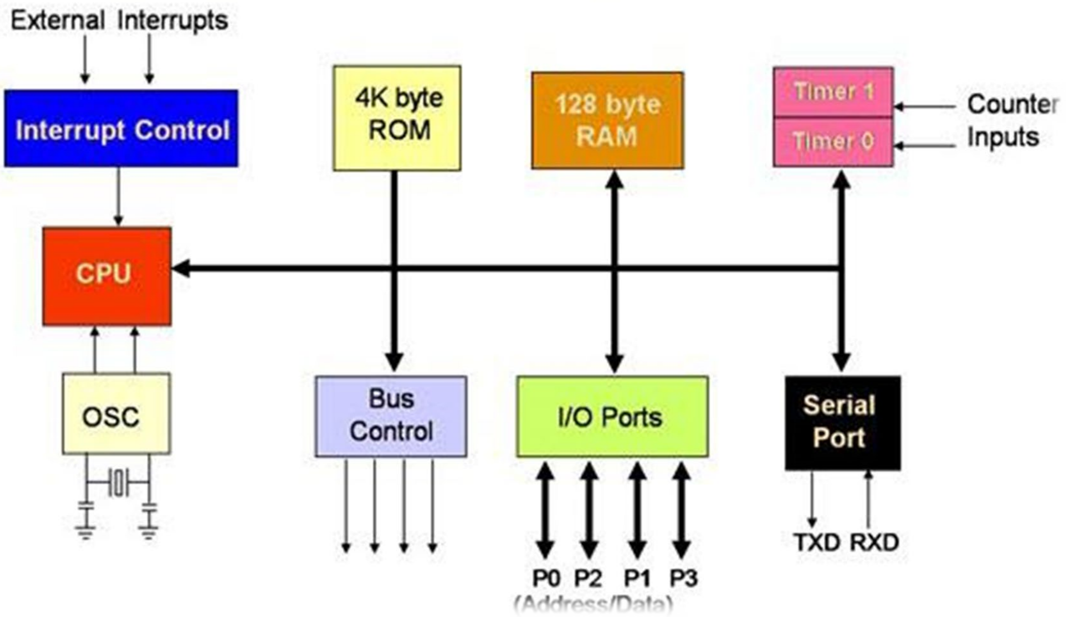
- The code correspondingly used to carry out this project were run on edsim51 simulator.
- The logical diagrams corresponding to the project are based on the edsim51 simulator.

CHAPTER – DESCRIPTION OF THE COMPONENTS USED

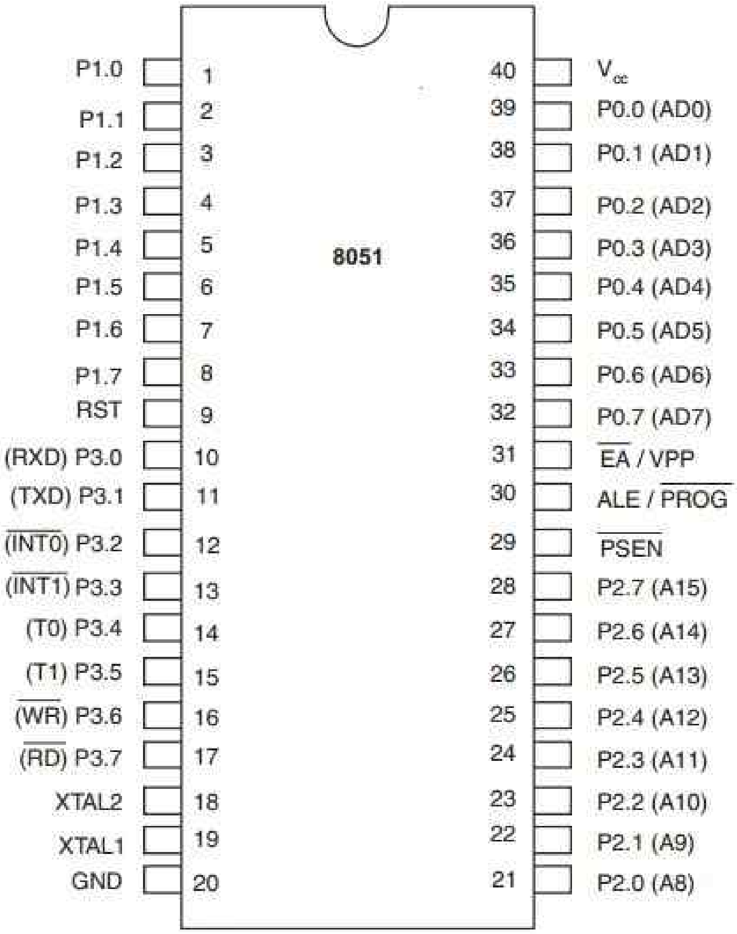
8051 MCU – AT89C52

- 8051 microcontroller is a 8-bit microcontroller.
- The features of 8051 microcontroller are as follows:
  i) 4kB on chip program memory
  ii) 128 bytes on-chip data memory (RAM)
  iii) Four register banks
  iv) 128 user defined software flags
  v) 8-bit bidirectional data bus
  vi) 16-bit unidirectional address bus
  vii) 32 general purpose registers each of 8-bit
  viii) 16-bit Timers (usually 2, but may have more or less)
  ix) Three internal and two external Interrupts
  x) Four 8-bit ports, (short model have two 8-bit ports)
  xi) 16-bit program counter and data pointer
  xii) 8051 may also have a number of special features such as UARTs, ADC, Op-amp, etc.
- 8051 microcontroller family members has 3 more types of microcontrollers – 8051, 8052 and 8031

The following illustration shows the block diagram of an 8051 microcontroller −



The pin diagram of 8051 microcontroller is shown is the figure below –

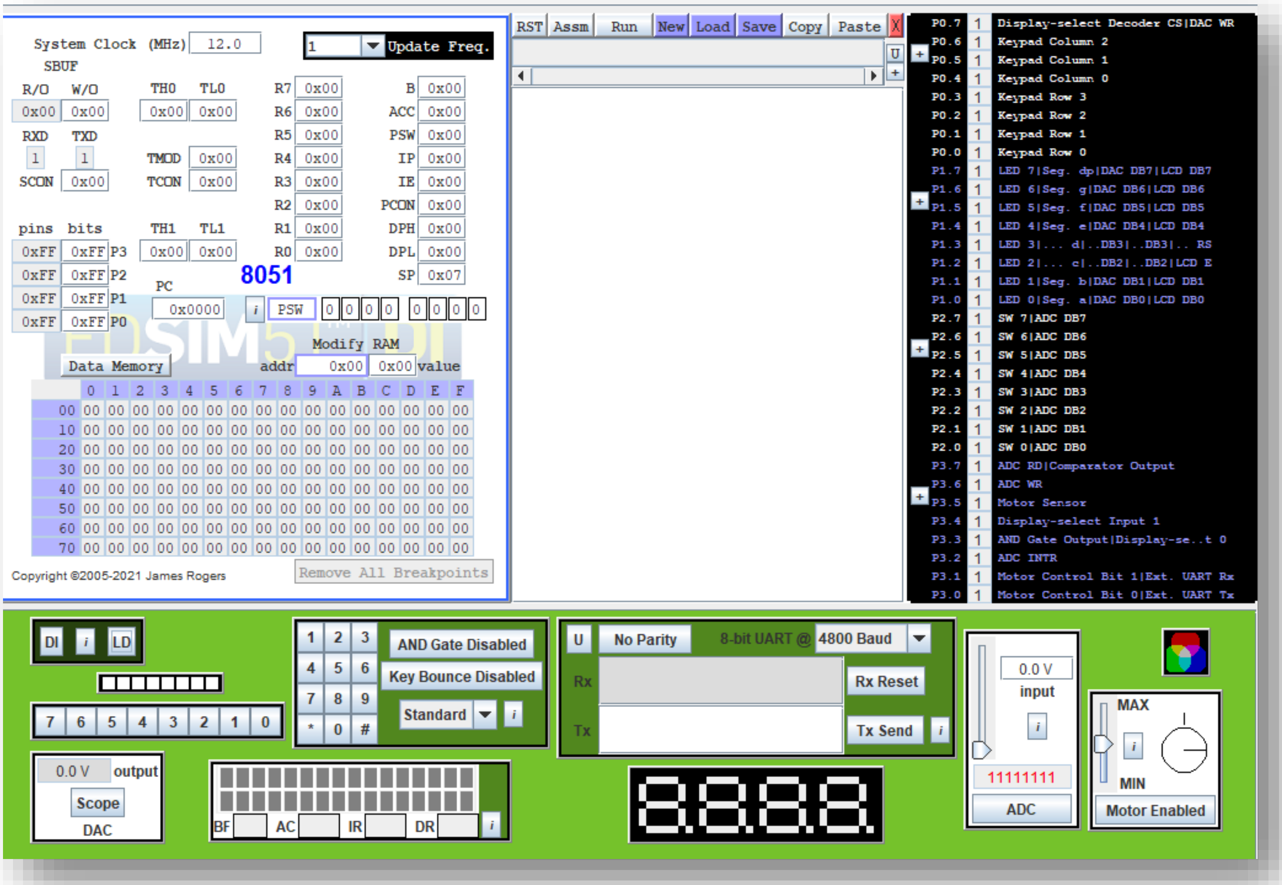


The pin description along with the pin numbering is being discussed in the following table:

SL.NO.	PIN NUMBERS	DESCRIPTION
1.	Pin 1 - 8	These pins are known as Port 1. This port doesn't serve any other functions. It is internally pulled up, bi-directional I/O port.
2.	Pin 9	It is a RESET PIN, used to reset the microcontroller to its initial values.
3.	Pin 10 - 17	Known as Port 3, these ports serves some functions like interrupts, timer input, control signals, serial communication signals RxD and TxD, etc
4.	Pin 18 & 19	These pins are used for interfacing an external crystal to get the system clock.
5.	Pin 20	Provides the power supply to the circuit.
6.	Pin 21 - 28	Known as Port 2 , they served as I/O port.
7.	Pin 29	PSEN pin which is used to read a signal from external program memory.
8.	Pin 30	EA pin which is used to enable/disable the external memory interfacing
9.	Pin 31	ALE pin which is used to demultiplex the address-data signal of port
10.	Pin 32 - 39	Known as Port 0
11.	Pin 40	Used to provide power supply to the circuit

- An addressing made is a way to locate a target data, which is also called as operand. The 8051 family of microcontrollers allows five types of addressing modes for addressing operands. They are as follows:
  i) Immediate Addressing
  ii) Register Addressing
  iii) Direct Addressing
  iv) Register-Indirect Addressing
  v) Indexed Addressing
- Coming to the operand part of the instruction, it defines the data being processed by the instructions. The operand can be any of the following:
  A. No Operand
  B. Data Value
  C. I/O Port
  D. Memory Location
  E. CPU Register
- Based on the operations they perform, all the instructions in 8051 microcontroller instruction set are divided into five groups:
  A. Data Transfer Instruction
  B. Arithmetic Instruction
  C. Logical Instructions
  D. Boolean or bit Manipulation Instructions
  E. Program Branching Instructions.

EDSIM51



System Clock (MHz) 12.0 | 1 Update Freq.

SBUF R/O 0x00 W/O 0x00

RXD 1 TXD 1

SCON 0x00

TH0 0x00 TL0 0x00

TMOD 0x00

TCON 0x00

TH1 0x00 TL1 0x00

pins	bits	
0xFF	0xFF	P3
0xFF	0xFF	P2
0xFF	0xFF	P1
0xFF	0xFF	P0

R7 0x00 R6 0x00 R5 0x00 R4 0x00 R3 0x00 R2 0x00 R1 0x00 R0 0x00

B 0x00 ACC 0x00 PSW 0x00 IP 0x00 IE 0x00 PCON 0x00 DPH 0x00 DPL 0x00 SP 0x07

PC 0x0000

PSW 0 0 0 0 0 0 0 0

Modify RAM addr 0x00 0x00 value

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
10	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
20	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
30	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
40	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
50	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
60	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
70	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

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P0.7	1	Display-select Decoder CS|DAC WR
P0.6	1	Keypad Column 2
P0.5	1	Keypad Column 1
P0.4	1	Keypad Column 0
P0.3	1	Keypad Row 3
P0.2	1	Keypad Row 2
P0.1	1	Keypad Row 1
P0.0	1	Keypad Row 0
P1.7	1	LED 7|Seg. dp|DAC DB7|LCD DB7
P1.6	1	LED 6|Seg. g|DAC DB6|LCD DB6
P1.5	1	LED 5|Seg. f|DAC DB5|LCD DB5
P1.4	1	LED 4|Seg. e|DAC DB4|LCD DB4
P1.3	1	LED 3|... d|..DB3|..DB3|.. RS
P1.2	1	LED 2|... c|..DB2|..DB2|LCD E
P1.1	1	LED 1|Seg. b|DAC DB1|LCD DB1
P1.0	1	LED 0|Seg. a|DAC DB0|LCD DB0
P2.7	1	SW 7|ADC DB7
P2.6	1	SW 6|ADC DB6
P2.5	1	SW 5|ADC DB5
P2.4	1	SW 4|ADC DB4
P2.3	1	SW 3|ADC DB3
P2.2	1	SW 2|ADC DB2
P2.1	1	SW 1|ADC DB1
P2.0	1	SW 0|ADC DB0
P3.7	1	ADC RD|Comparator Output
P3.6	1	ADC WR
P3.5	1	Motor Sensor
P3.4	1	Display-select Input 1
P3.3	1	AND Gate Output|Display-se..t 0
P3.2	1	ADC INTR
P3.1	1	Motor Control Bit 1|Ext. UART Rx
P3.0	1	Motor Control Bit 0|Ext. UART Tx

0.0 V output

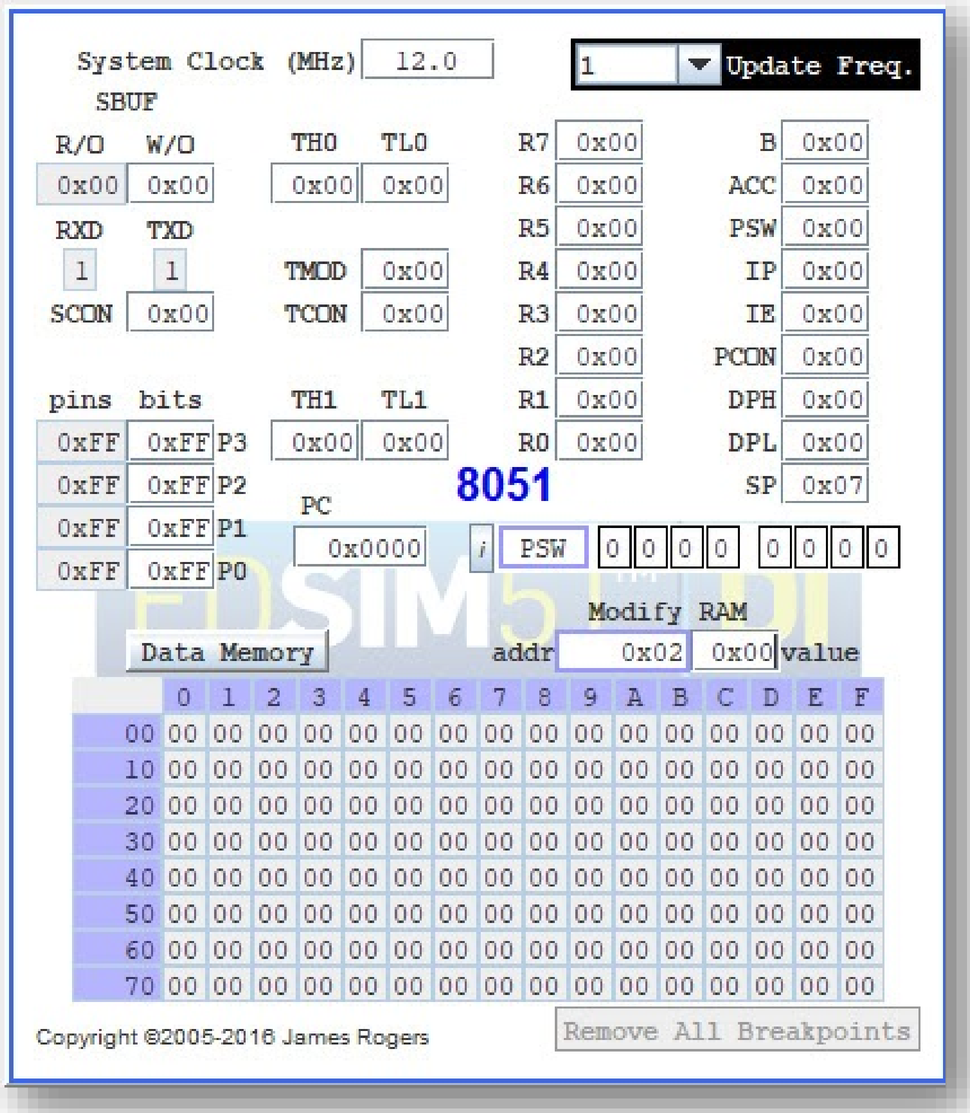
8-bit UART @ 4800 Baud

0.0 V input

11111111

- Edsim51 is a widely used simulation software for programming of 8051.
- The various parts of edsim51 are as follows:
  A) Registers and Internal RAM
  B) Programming Section
  C) Port Connections
  D) Sensors and Actuators

- REGISTERS AND INTERNAL RAM-
  1. The upper parts depict different registers such as general-purpose registers (R0-R7), SFRs.
  2. A memory map of internal RAM which is 128 bytes meaning 128 locations, starting from 0x00, 0x01,….,0x0F (ROW-1) . Similarly, there are 8 rows.



System Clock (MHz) 12.0

1 Update Freq.

SBUF

R/O 0x00 W/O 0x00

RXD 1 TXD 1

SCON 0x00

TH0 0x00 TL0 0x00

TMOD 0x00

TCON 0x00

TH1 0x00 TL1 0x00

pins	bits	
0xFF	0xFF	P3
0xFF	0xFF	P2
0xFF	0xFF	P1
0xFF	0xFF	P0

R7	0x00	B	0x00
R6	0x00	ACC	0x00
R5	0x00	PSW	0x00
R4	0x00	IP	0x00
R3	0x00	IE	0x00
R2	0x00	PCON	0x00
R1	0x00	DPH	0x00
R0	0x00	DPL	0x00
		SP	0x07

8051

PC 0x0000

PSW 0 0 0 0 0 0 0 0

Modify RAM addr 0x02 value 0x00

Data Memory

	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
10	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
20	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
30	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
40	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
50	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
60	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00
70	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00

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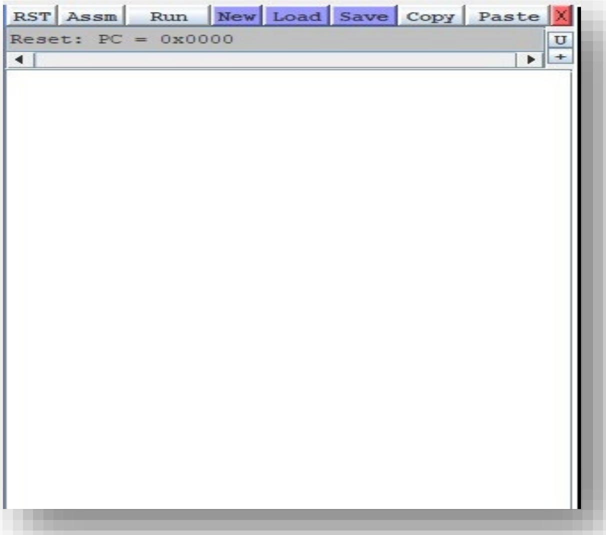
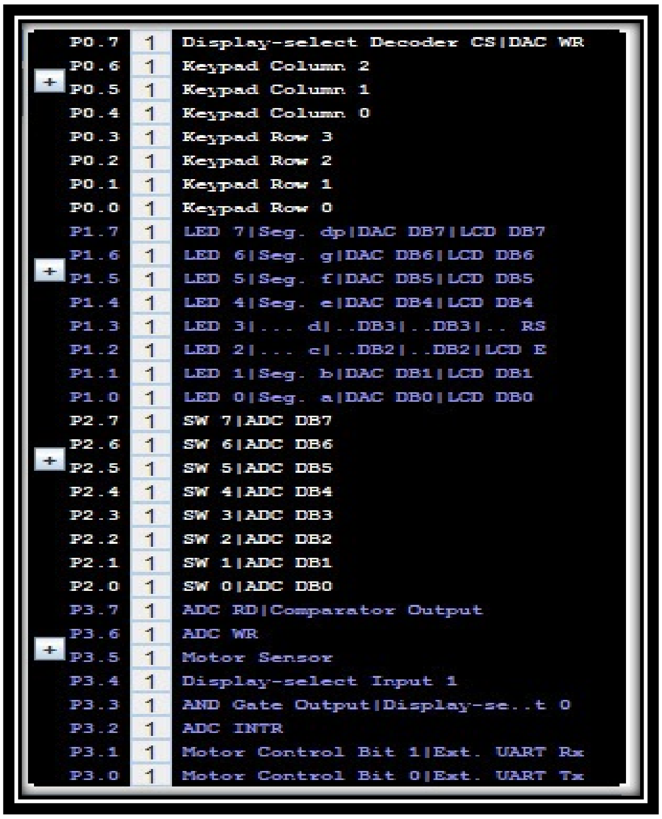
- PROGRAMMING SECTIONS-
  1. Once the program is written, save the program into the PC’s local storage.
  2. Program also can be loaded from the memory.
  3. After typing the program, run it.
  4. Check the register values and memory locations.
  5. Click RST to come back to the edit part.



```
Reset: PC = 0x0000
```

PORT INTERFACE-



P0.7	1	Display-select Decoder CS|DAC WR
P0.6	1	Keypad Column 2
P0.5	1	Keypad Column 1
P0.4	1	Keypad Column 0
P0.3	1	Keypad Row 3
P0.2	1	Keypad Row 2
P0.1	1	Keypad Row 1
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P1.6	1	LED 6|Seg. g|DAC DB6|LCD DB6
P1.5	1	LED 5|Seg. f|DAC DB5|LCD DB5
P1.4	1	LED 4|Seg. e|DAC DB4|LCD DB4
P1.3	1	LED 3|... d|..DB3|..DB3|.. RS
P1.2	1	LED 2|... c|..DB2|..DB2|LCD E
P1.1	1	LED 1|Seg. b|DAC DB1|LCD DB1
P1.0	1	LED 0|Seg. a|DAC DB0|LCD DB0
P2.7	1	SW 7|ADC DB7
P2.6	1	SW 6|ADC DB6
P2.5	1	SW 5|ADC DB5
P2.4	1	SW 4|ADC DB4
P2.3	1	SW 3|ADC DB3
P2.2	1	SW 2|ADC DB2
P2.1	1	SW 1|ADC DB1
P2.0	1	SW 0|ADC DB0
P3.7	1	ADC RD|Comparator Output
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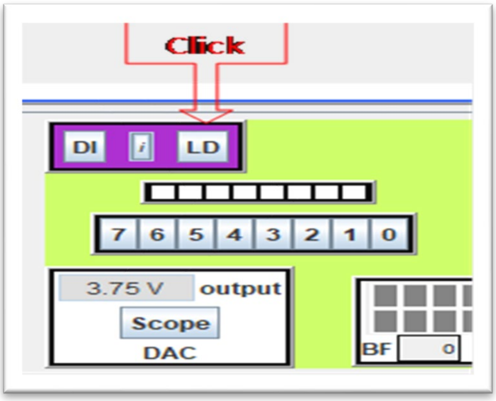
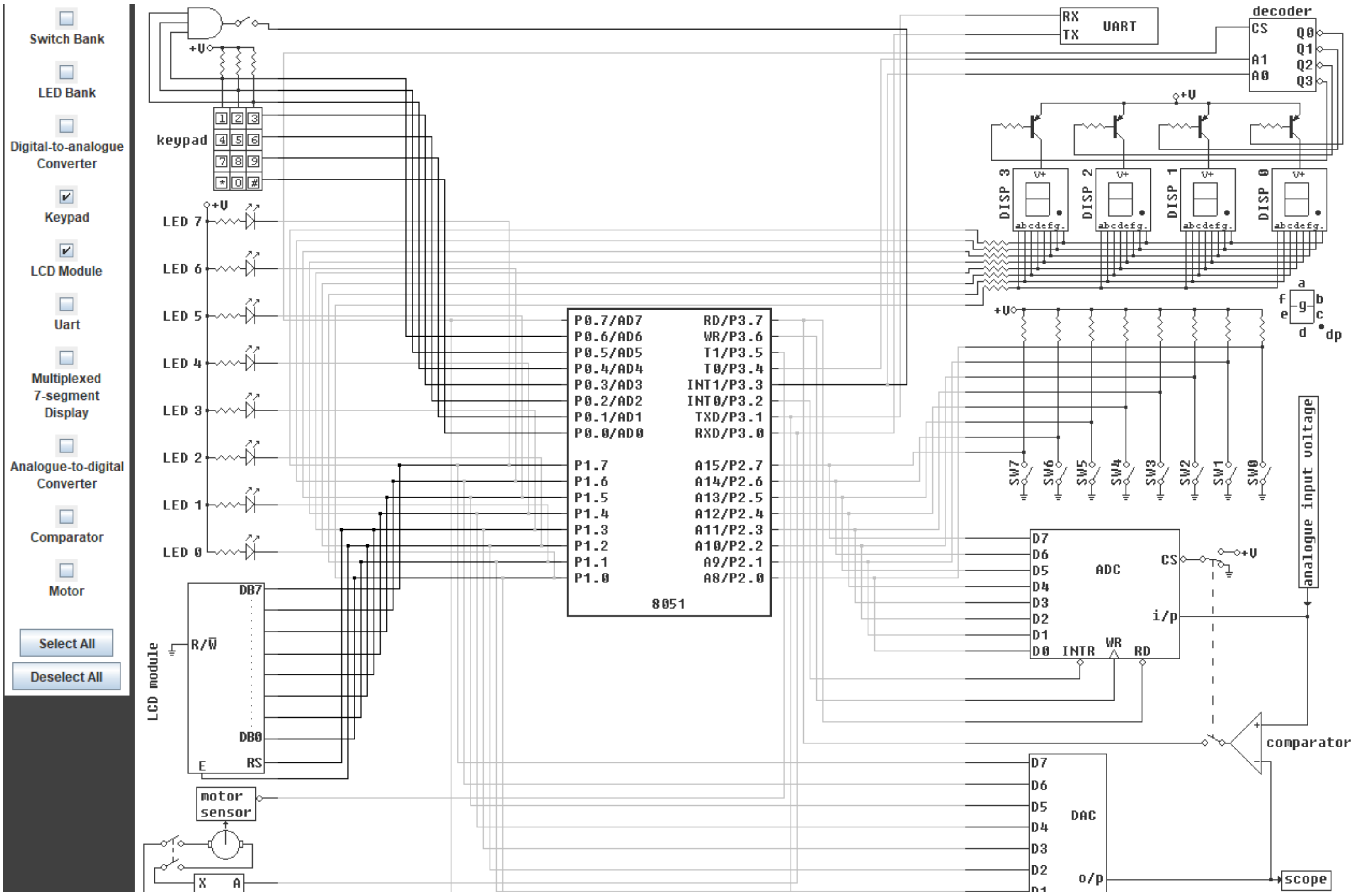
P3.1	1	Motor Control Bit 1|Ext. UART Rx
P3.0	1	Motor Control Bit 0|Ext. UART Tx

Logic Diagram




□ Switch Bank

□ LED Bank

□ Digital-to-analogue Converter

☑ Keypad

☑ LCD Module

□ Uart

□ Multiplexed 7-segment Display

□ Analogue-to-digital Converter

□ Comparator

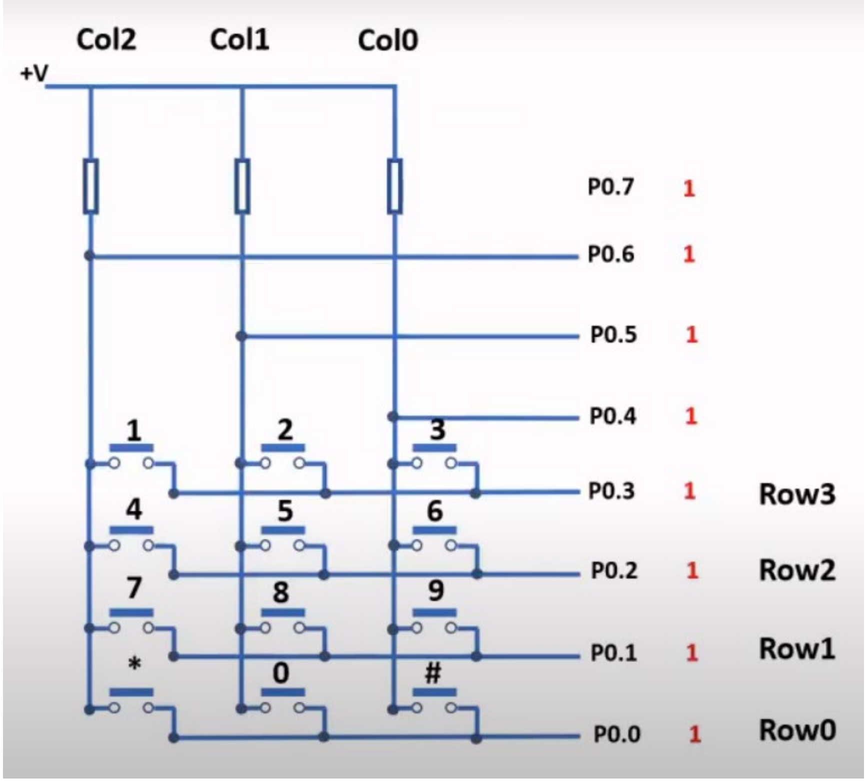
□ Motor

Select All

Deselect All

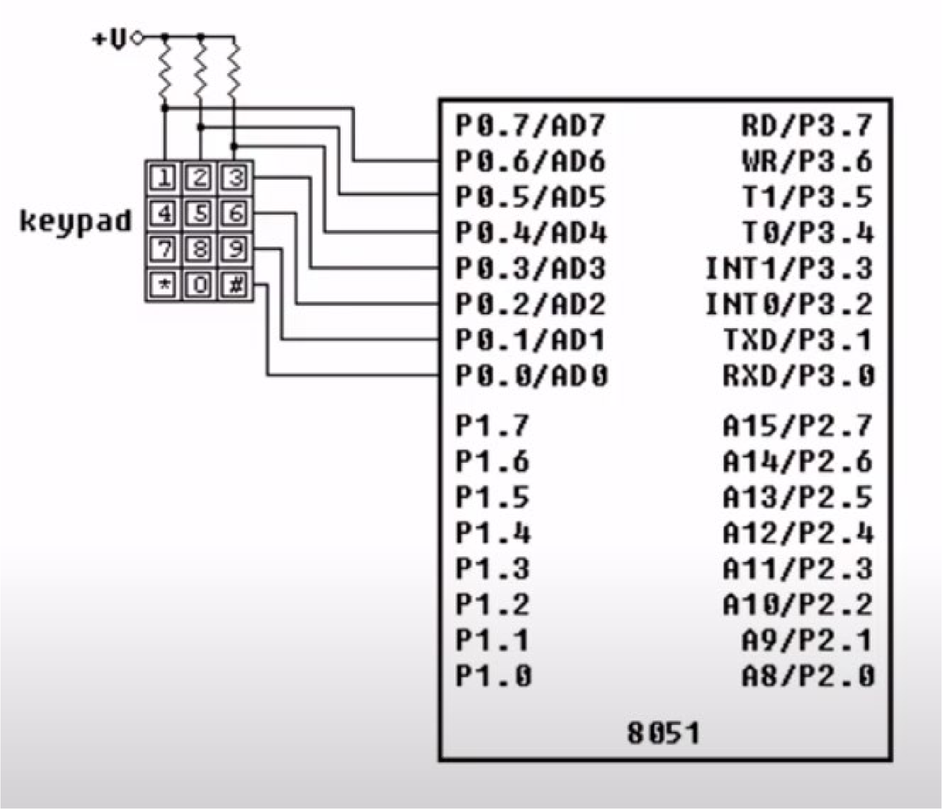
MATRIX KEYPAD(4X3)

- Most of the applications of embedded systems require keypads to take the user inputs, especially in case where an application requires a greater number of keys.
- With simple architecture and easy interfacing procedure, matrix keypads are replacing normal push-buttons by offering more inputs to the user with the lesser I/O pins.
- A matrix keypad consists of a set of push button or switches which are arranged in a matrix format of rows and columns.
- These keypads are available in configurations like 3×4 and 4×4 based on the application it is implemented for. Internal diagram of this matrix keypad is shown in the below figure-



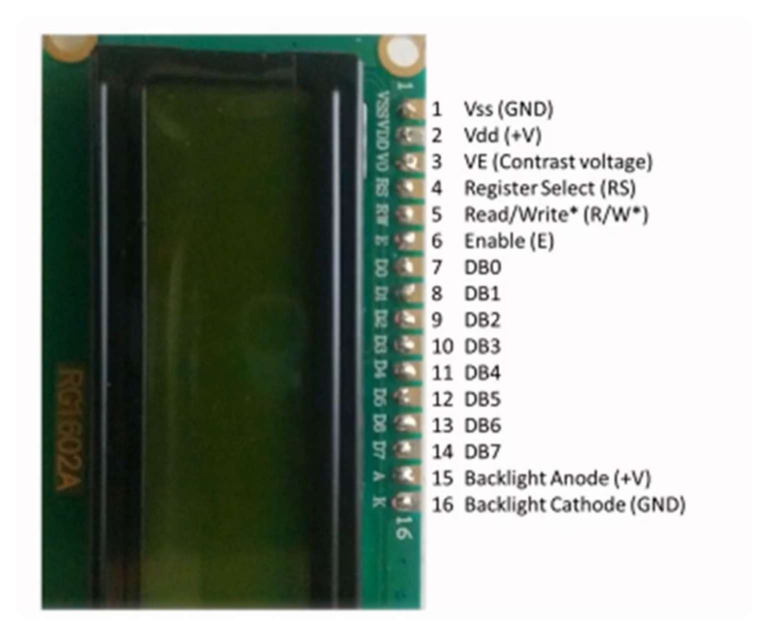
- Matrix keypad can be connected to the microcontroller in numerous ways or techniques, but the fundamental logic is same as making the columns as input and the rows as output.
- So, in order to detect the key pressed from the keypad, the row lines have to be made low one by one and to read the columns.

MATRIX KEYPAD INTERFACE WITH MICROCONTROLLER-



1. Make sure that the all the rows of port 1 high in order to give the signal to microcontroller when any key is pressed.
2. The working of the keypad goes like this: If any of the keys in row1 of the matrix keypad is pressed, the corresponding column line will give low and similarly if the second key is pressed in row1, then the column line 2 will give low. This process is repeated for all the rows.
3. When the circuit is powered and any key is pressed, then corresponding pins of the port 1 get enabled. Depending on the program in the microcontroller, it displays the number.

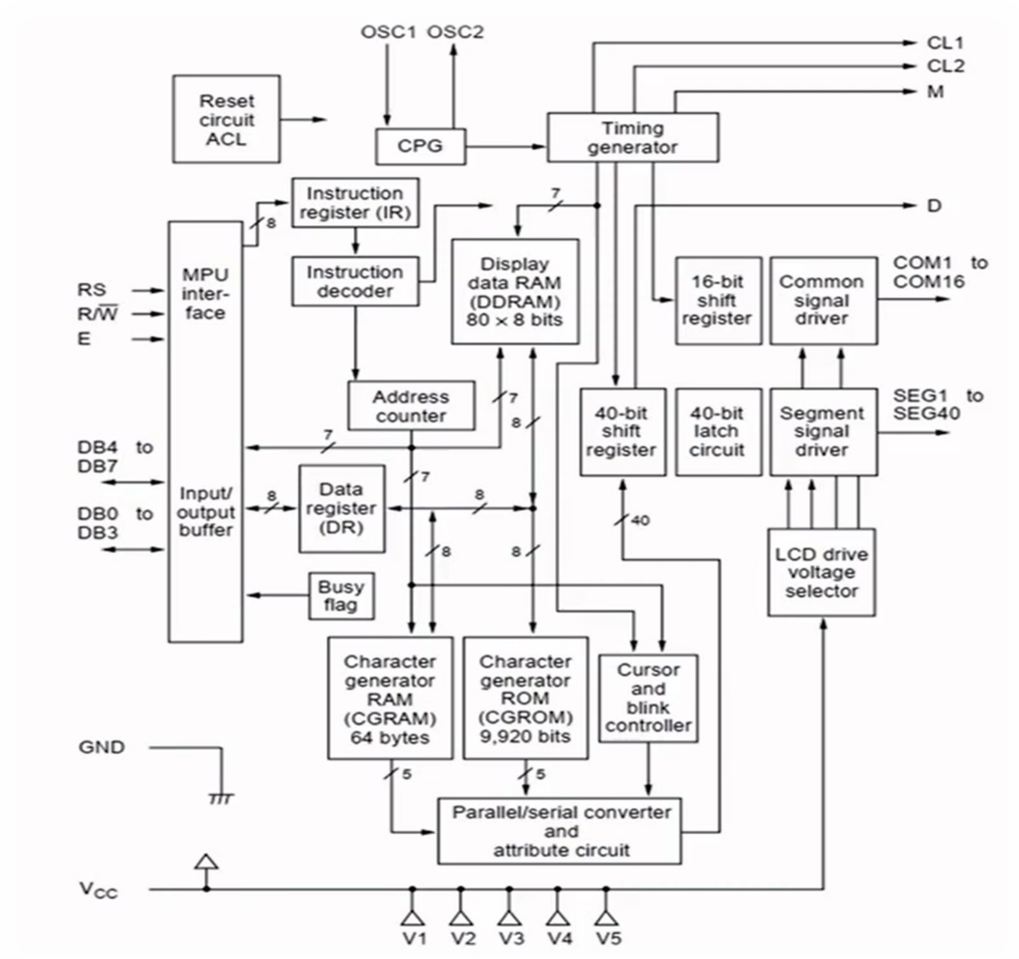
HITACHI HD44780U LCD MODULE:



- The HD44780U dot-matrix LCD controller and driver LSI displays alphanumeric, kana characters and symbols.
- It can be configured to drive a dot-matrix LCD under the control of a 4 or 8 bit microprocessor / microcontroller.
- The low power supply (2.7V to 5.5V) of the HD44780U is suitable for any portable battery-driven product requiring low power dissipation.
- FEATURES –
- 5 × 8 and 5 × 10 dot matrix possible.
- Low power operation support: 2.7 to 5.5V.
- Corresponds to high speed MPU bus interface - 2MHz.
- Supports wide range of instruction functions.
- Automatic reset ckt that initialises the controller/driver after power on.

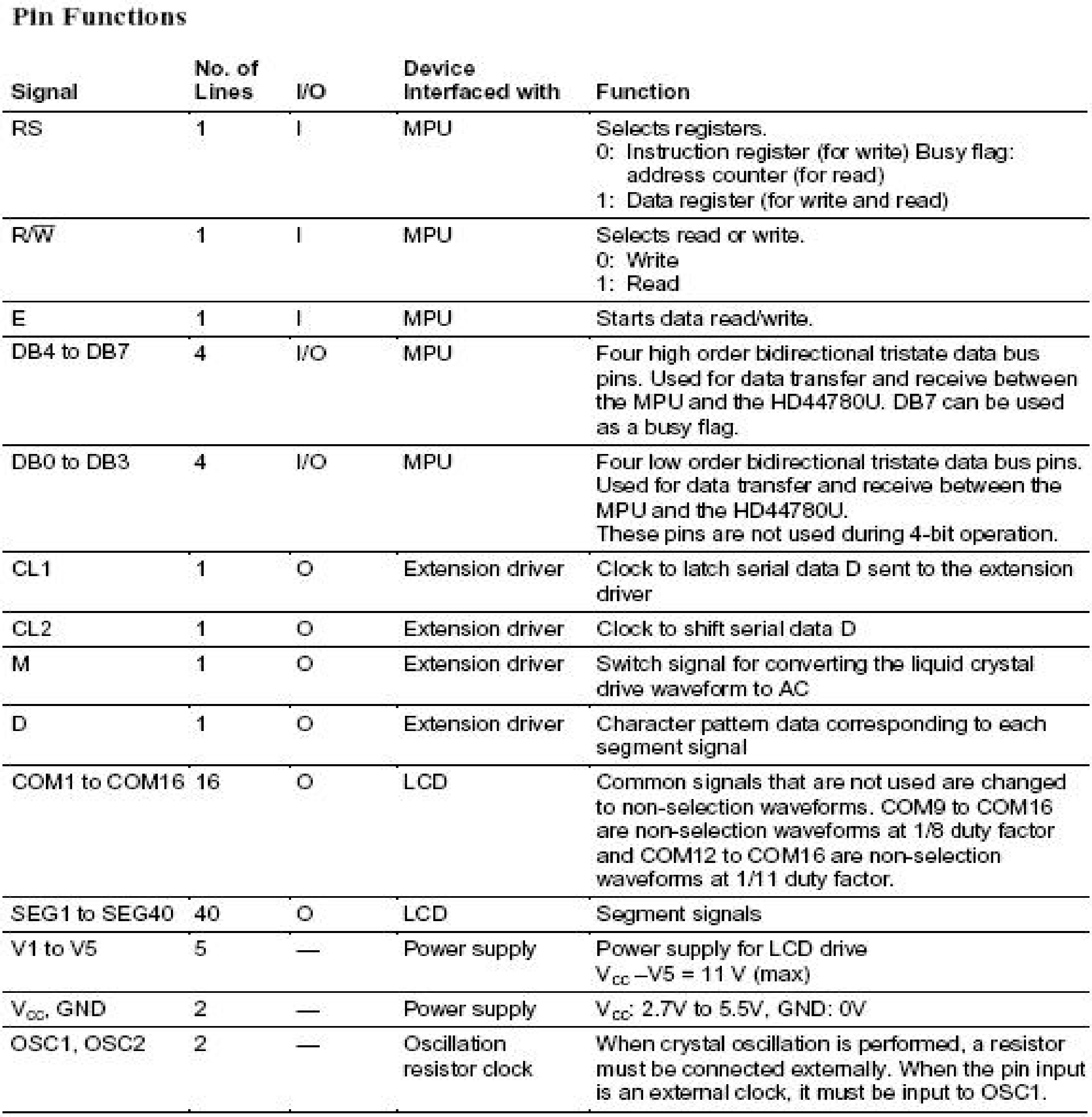
The block diagram of HD44780U is shown in the given diagram:

- **4-bit Mode:** The LCD module is a simulation of the Hitachi HD44780 and is interfaced to the 8051 in 4-bit mode. P1.7 through P1.4 are connected to DB7 through DB4, while P1.3 is connected to the register-select pin and P1.2 is connected to the enable pin. Notice the read-write pin is connected to ground - the module can only be written to.



- **8-bit Mode:** By default, as stated above, the module is interfaced in 4-bit mode. However, the lower four data bits (DB3 through DB0) are also available (on P1.3 through P1.0). If the user wishes to write to the module in 8-bit mode, RS and E should be remapped to other port pins.

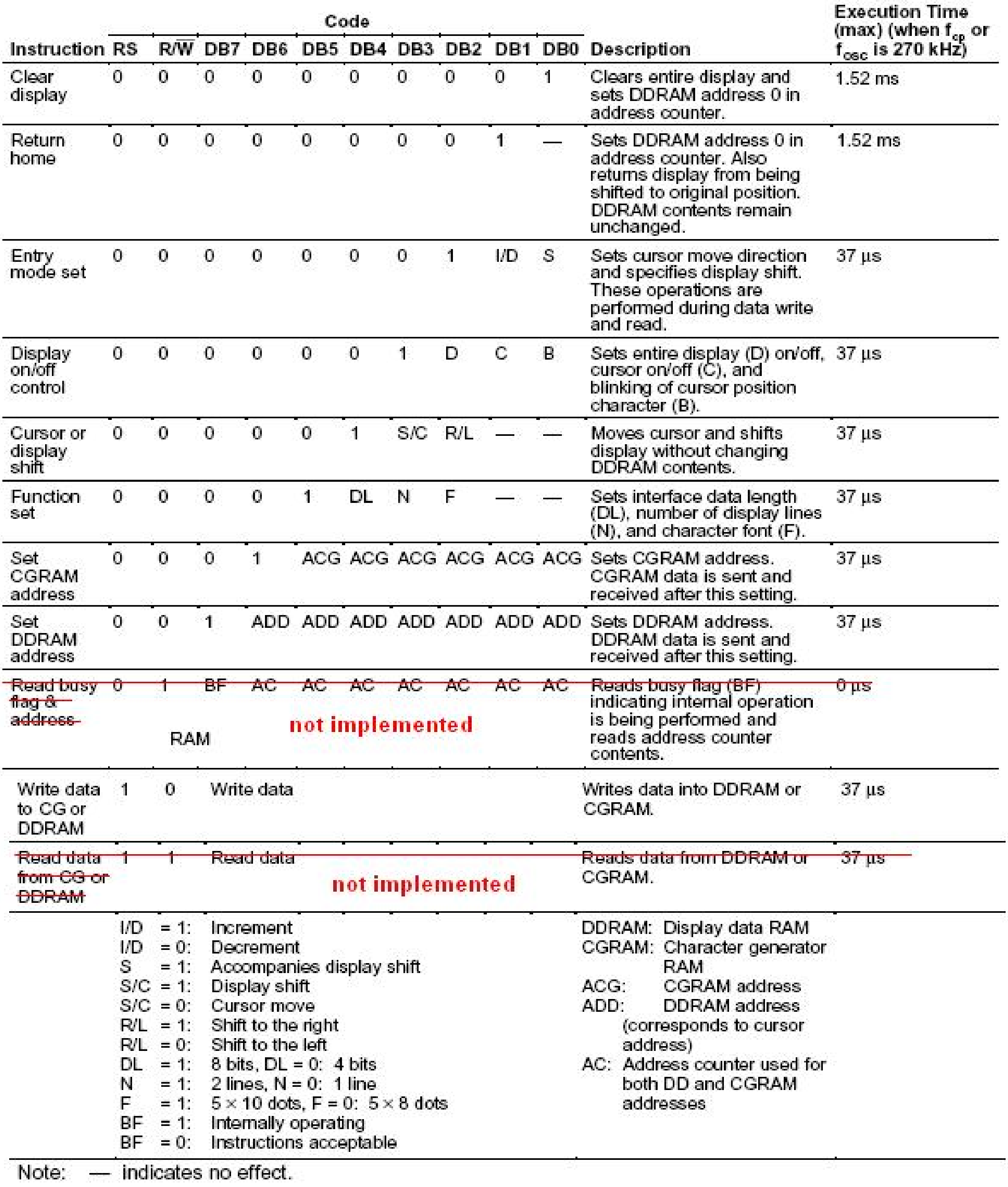
The pin description of the LCD provided in edsim51 is given below:



Pin Functions

Signal	No. of Lines	I/O	Device Interfaced with	Function
RS	1	I	MPU	Selects registers. 0: Instruction register (for write) Busy flag: address counter (for read) 1: Data register (for write and read)
R/$\overline{\text{W}}$	1	I	MPU	Selects read or write. 0: Write 1: Read
E	1	I	MPU	Starts data read/write.
DB4 to DB7	4	I/O	MPU	Four high order bidirectional tristate data bus pins. Used for data transfer and receive between the MPU and the HD44780U. DB7 can be used as a busy flag.
DB0 to DB3	4	I/O	MPU	Four low order bidirectional tristate data bus pins. Used for data transfer and receive between the MPU and the HD44780U. These pins are not used during 4-bit operation.
CL1	1	O	Extension driver	Clock to latch serial data D sent to the extension driver
CL2	1	O	Extension driver	Clock to shift serial data D
M	1	O	Extension driver	Switch signal for converting the liquid crystal drive waveform to AC
D	1	O	Extension driver	Character pattern data corresponding to each segment signal
COM1 to COM16	16	O	LCD	Common signals that are not used are changed to non-selection waveforms. COM9 to COM16 are non-selection waveforms at 1/8 duty factor and COM12 to COM16 are non-selection waveforms at 1/11 duty factor.
SEG1 to SEG40	40	O	LCD	Segment signals
V1 to V5	5	—	Power supply	Power supply for LCD drive V_{CC} –V5 = 11 V (max)
V_{CC}, GND	2	—	Power supply	V_{CC}: 2.7V to 5.5V, GND: 0V
OSC1, OSC2	2	—	Oscillation resistor clock	When crystal oscillation is performed, a resistor must be connected externally. When the pin input is an external clock, it must be input to OSC1.

The instruction set of LCD Module is discussed below-



	Code											Execution Time (max) (when f_{cp} or f_{osc} is 270 kHz)
Instruction	RS	$R/\overline{W}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Description	
Clear display	0	0	0	0	0	0	0	0	0	1	Clears entire display and sets DDRAM address 0 in address counter.	1.52 ms
Return home	0	0	0	0	0	0	0	0	1	—	Sets DDRAM address 0 in address counter. Also returns display from being shifted to original position. DDRAM contents remain unchanged.	1.52 ms
Entry mode set	0	0	0	0	0	0	0	1	I/D	S	Sets cursor move direction and specifies display shift. These operations are performed during data write and read.	37 µs
Display on/off control	0	0	0	0	0	0	1	D	C	B	Sets entire display (D) on/off, cursor on/off (C), and blinking of cursor position character (B).	37 µs
Cursor or display shift	0	0	0	0	0	1	S/C	R/L	—	—	Moves cursor and shifts display without changing DDRAM contents.	37 µs
Function set	0	0	0	0	1	DL	N	F	—	—	Sets interface data length (DL), number of display lines (N), and character font (F).	37 µs
Set CGRAM address	0	0	0	1	ACG	ACG	ACG	ACG	ACG	ACG	Sets CGRAM address. CGRAM data is sent and received after this setting.	37 µs
Set DDRAM address	0	0	1	ADD	ADD	ADD	ADD	ADD	ADD	ADD	Sets DDRAM address. DDRAM data is sent and received after this setting.	37 µs
~~Read busy flag & address~~	~~0~~	~~1~~ RAM	~~BF~~	~~AC~~	~~AC~~	~~AC~~ not implemented	~~AC~~	~~AC~~	~~AC~~	~~AC~~	~~Reads busy flag (BF)~~ indicating internal operation is being performed and reads address counter contents.	~~0 µs~~
Write data to CG or DDRAM	1	0	Write data								Writes data into DDRAM or CGRAM.	37 µs
~~Read data from CG or DDRAM~~	~~1~~	~~1~~	~~Read data~~			not implemented					~~Reads data from DDRAM or~~ CGRAM.	~~37 µs~~

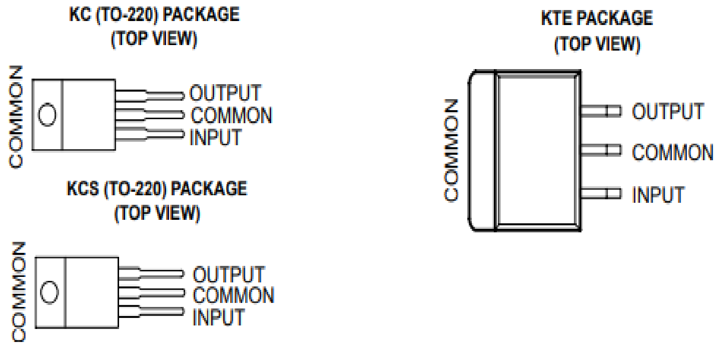
I/D	= 1:	Increment	DDRAM:	Display data RAM
I/D	= 0:	Decrement	CGRAM:	Character generator RAM
S	= 1:	Accompanies display shift	ACG:	CGRAM address
S/C	= 1:	Display shift	ADD:	DDRAM address (corresponds to cursor address)
S/C	= 0:	Cursor move	AC:	Address counter used for both DD and CGRAM addresses
R/L	= 1:	Shift to the right		
R/L	= 0:	Shift to the left		
DL	= 1:	8 bits, DL = 0: 4 bits		
N	= 1:	2 lines, N = 0: 1 line		
F	= 1:	5 × 10 dots, F = 0: 5 × 8 dots		
BF	= 1:	Internally operating		
BF	= 0:	Instructions acceptable		

Note: — indicates no effect.

PUSH BACK SWITCH

- A simple Push Back Switch is a type of switch which consists of a simple electric mechanism or air switch mechanism to turn something on or off.
- Depending on model they could operate with momentary or latching action function.
- The button itself is usually constructed of a strong durable material such as metal or plastic.
- Push back switches come in a range of shapes and sizes.
- Push back switches are used throughout industrial and medical applications and are also recognisable in everyday life.
- For uses within the industrial sector, push back switches often part of a bigger system and are connected through mechanical linkage.
- This means that when a button is pressed it can cause another button to release.

LM7805



- This series of fixed-voltage integrated-circuit voltage regulators is designed for a wide range of applications.
- These applications include on-card regulation for elimination of noise and distribution problems associated with single-point regulations.
- Each of these regulators can deliver up to 1.5 A of output current.
- The internal current-limiting and thermal-shutdown features of these regulators essentially make them immune to overload.
- In addition to use as fixed-voltage regulators, these devices can be used with external components to obtain adjustable output voltages and currents, and also can be used as the power-pass element in precision regulators.
- Features of LM78705:
  - i) 3 terminal regulators.
  - ii) Output Current up is 1.5A
  - iii) Internal-thermal overload production
  - iv) High power-dissipation capacity
  - v) Internal short-circuit current limiting.
  - vi) Output Transistor SAFE-Area Compensation.

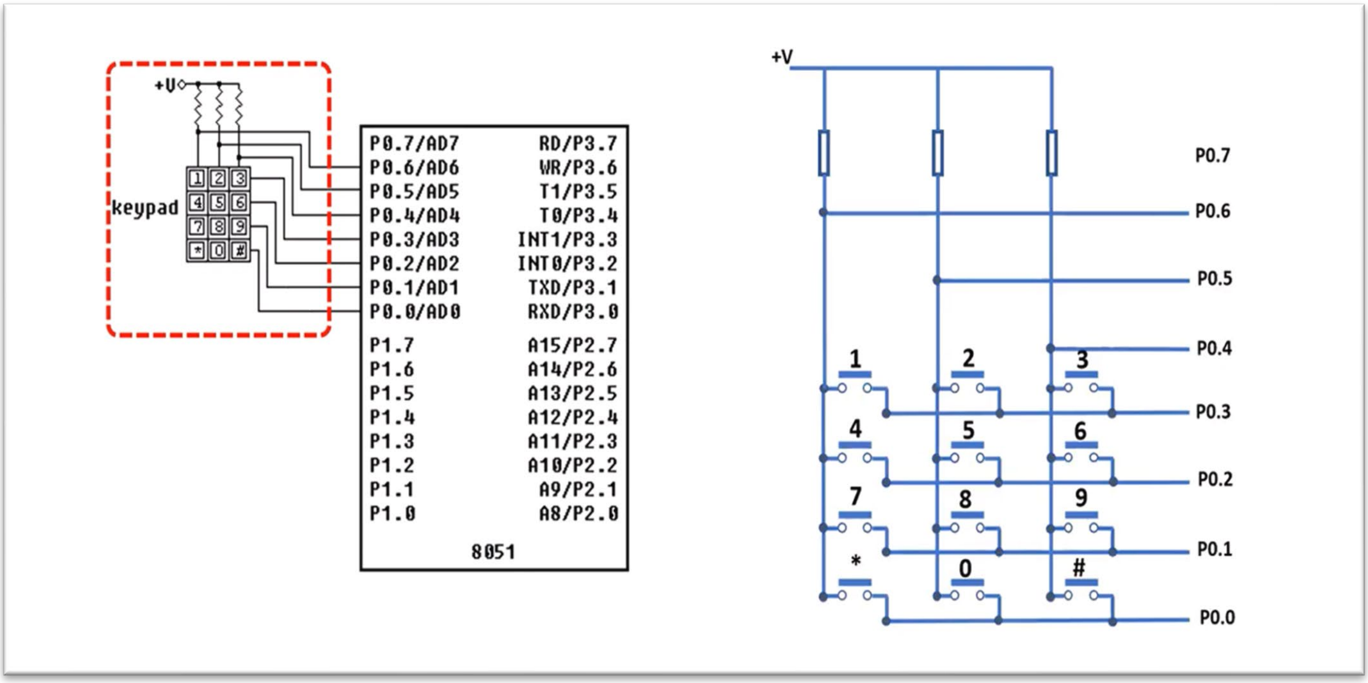
MAIN PROGRAM

```
Org 0000h

E       Equ  P1.2      ; pin P1.2 is assigned for Enable
RS      Equ  P1.3      ; pin P1.3 is assigned for Register select
N1      Equ  30H       ;stores first digit of first operand
N2      Equ  32H       ;stores second digit of first operand
N3      Equ  34H       ;stores first digit of second operand
N4      Equ  36H       ;stores second digit of second operand
N5      Equ  40H       ;stores result after calculation
N6      Equ  42H       ;stores quotient of result
N7      Equ  44H       ;stores remainder of result

  ; ----------------------------------- Main ---------------------------------------;

Main:
Clr RS                 ; RS=0 - Instruction register (I/R) is selected.
Call MemInit           ;Calls the memory initialisation subroutine and
                         clears all the garbage value.

  ;-------------------------- Instructions Code ----------------------------------;

Call FuncSet           ; Function set (selecting the 4-bit mode)

Call DispCon           ; Turn display and cusor on/off

Call EntryMode         ; Entry mode set - shift cursor to the right

  ;-------------------------------- Scan for the keys -----------------------------;
Next:
Call ScanKeyPad        ; calls the scan keypad subroutine
SetB RS                ; RS=1 - Data register is selected.

Clr A
```

```
Mov A,R7                ; move the pressed key to accumulator
Call SendChar           ; Display the key that is pressed.
Call operand            ;stores the 1st and 2nd operand in R3 & R5

EndHere: Jmp Next

  ;---------------------------------- *End Of Main* ------------------------------;
```

INTERFACING THE KEYPAD WITH 8051 MICROCONTROLLER

The interface between the keypad and the 8051 microcontroller is shown in the diagram below:



In edsim, the keypad uses the port 0 of the 8051 microcontrollers out of which pin P0.0 to P0.6 is being used and P0.7 is left unused. Pin p0.0 - pin p0.3 are connected to row0, row1, row2, row3 respectively & P0.4 – P0.6 are connected to Col0, Col1, Col2 respectively.

Initially all pins from p0.0 to pin 0.6 are set high (logic 1). When scanning the Row0, pin P0.0 is made low (logic 0), and let's assume that key # is pressed. So, on pressing #, it will short the Row0 and Col0 and simultaneously pin P0.4 will automatically go low. Hence the microcontroller will detect that p0.4 is low i.e. The key pressed is #.

The assembly language code for the interfacing of the keypad is discussed below:

```
;                     Col2 Col1 Col0
;                    +----+----+----+
;                    | 1  |2  | 3|   Row3
;                    +----+----+----+
;                    | 4| 5| 6|  Row2
;                    +----+----+----+
;                    | 7| 8| 9|  Row1
;                    +----+----+----+
;                    | *| 0| #|  Row0
;                    +----+----+----+

;------------------------------------ Scan Row --------------------------------------;

ScanKeyPad:
                                        ;Scan Row3
CLR P0.3                                ;Clear Row3
CALL IDCode0                            ;Call scan column subroutine
SetB P0.3                               ;Set Row 3
JB F0,Done                              ;If F0 is set, end scan

                                        ;Scan Row2
CLR P0.2                                ;Clear Row2
CALL IDCode1                            ;Call scan column subroutine
SetB P0.2                               ;Set Row 2
JB F0, Done                             ;If F0 is set, end scan
```

```
                                                ;Scan Row1
CLR P0.1                                        ;Clear Row1
CALL IDCode2                                    ;Call scan column subroutine
SetB P0.1                                       ;Set Row 1
JB F0,Done                                      ;If F0 is set, end scan

                                                ;Scan Row0
CLR P0.0                                        ;Clear Row0
CALL IDCode3                                    ;Call scan column subroutine
SetB P0.0                                       ;Set Row 0
JB F0,Done                                      ;If F0 is set, end scan


JMP ScanKeyPad                                  ;Go back to scan Row3

Done:       Clr F0                              ;Clear F0 flag before exit
           Ret

;------------------------------------------------ Scan column subroutine ------------------------------------------------;

IDCode0:
                        JNB P0.4, KeyCode03                 ;If Col0 Row3 is cleared - key found
                        JNB P0.5, KeyCode13                 ;If Col1 Row3 is cleared - key found
                        JNB P0.6, KeyCode23                 ;If Col2 Row3 is cleared - key found
                        RET

KeyCode03:
                        SETB F0                             ;Key found - set F0
                        Mov R7,#'3'                         ;Code for '3'


;---------------- Checks the value of R6, and according to that it jumps to required subroutine--------------;


cjne R6,#00H, next1                 ; If R6 is 0, execute the next command, otherwise jump to next1
Mov N1,#03H                         ; stores this digit as digit 1 of operand 1 in N1 memory location
inc R6
ret

next1:
cjne R6,#01H, next2                 ; If R6 is 1, execute the next command, otherwise jump to next2
Mov N2,#03H                         ; stores this digit as digit 2 of operand 1 in N2 memory location
inc R6
ret

next2:
cjne R6,#02H, next3                 ; If R6 is 2, execute the next command, otherwise jump to next3
Mov N3,#03H                         ; stores this digit as digit 1 of operand 2 in N3 memory location
inc R6
ret
```

```
next3:
cjne R6,#03H, $         ; If R6 is 3, execute the next command, otherwise do nothing
Mov N4,#03H             ; stores this digit as digit 2 of operand 2 in N4 memory location
RET

KeyCode13:              SETB F0             ; Key found - set F0 flag
                        Mov R7,#'2'         ; Code for '2'

                        cjne R6,#00H, next4
                        Mov N1,#02H
                        inc R6
                        ret

next4:                  cjne R6,#01H, next5
                        Mov N2,#02H
                        inc R6
                        ret

next5:                  cjne R6,#02H, next6
                        Mov N3,#02H
                        inc R6
                        ret

next6:                  cjne R6,#03H, $
                        Mov N4,#02H
                        RET

KeyCode23:              SETB F0                     ;Key found - set F0
                        Mov R7,#'1'                 ;Code for '1'

                        cjne R6,#00H, next7
                        Mov N1,#01H
                        inc R6
                        ret

next7:                   cjne R6,#01H, next8
                         Mov N2,#01H
                         inc R6
                         ret

next8:                  cjne R6,#02H, next9
                         Mov N3,#01H
                         inc R6
                          ret

next9:                  cjne R6,#03H, $
                        Mov N4,#01H
                        RET

IDCode1:                JNB P0.4, KeyCode02                 ;If Col0 Row2 is cleared - key found
```

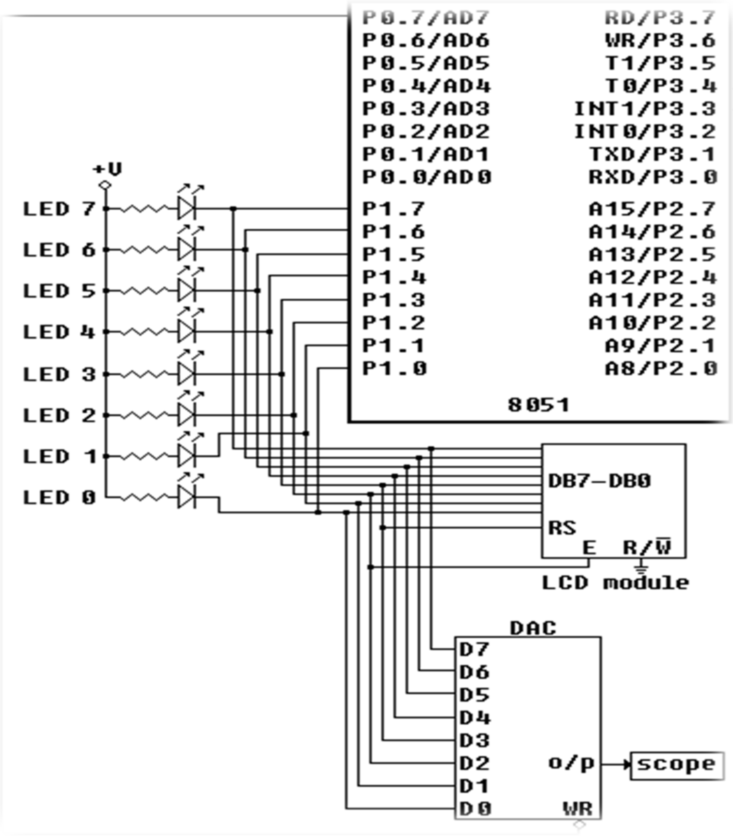
```
                JNB P0.5, KeyCode12             ;If Col1 Row2 is cleared - key found
                JNB P0.6, KeyCode22             ;If Col2 Row2 is cleared - key found
                RET

KeyCode02:      SETB F0                         ;Key found - set F0
                Mov R7,#'6'                     ;Code for '6'

                cjne R6,#00H, next10
                Mov N1,#06H
                inc R6

                ret

next10:         cjne R6,#01H, next11
                Mov N2,#06H
                inc R6
                ret

next11:         cjne R6,#02H, next12
                Mov N3,#06H
                inc R6
                ret

next12:         cjne R6,#03H, $
                Mov N4,#06H
                Ret

KeyCode12:      SETB F0                         ;Key found - set F0
                Mov R7,#'5'                     ;Code for '5'

                cjne R6,#00H, next13
                Mov N1,#05H
                inc R6
                ret

next13:         cjne R6,#01H, next14
                Mov N2,#05H
                inc R6
                ret

next14:         cjne R6,#02H, next15
                 Mov N3,#05H
                 inc R6
                 ret

next15:         cjne R6,#03H, $
                Mov N4,#05H
                RET

KeyCode22:      SETB F0                         ;Key found - set F0
                Mov R7,#'4'                     ;Code for '4'
                cjne R6,#00H, next16
                Mov N1,#04H
                inc R6
                ret

next16:         cjne R6,#01H, next17
                Mov N2,#04H
                inc R6
                ret

next17:         cjne R6,#02H, next18
                Mov N3,#04H
                inc R6
                ret

next18:         cjne R6,#03H, $
                Mov N4,#04H
                RET

IDCode2:        JNB P0.4, KeyCode01       ;If Col0 Row1 is cleared - key found
                JNB P0.5, KeyCode11       ;If Col1 Row1 is cleared - key found
                JNB P0.6, KeyCode21       ;If Col2 Row1 is cleared - key found
                RET

KeyCode01:      SETB F0                   ;Key found - set F0
                Mov R7,#'9'               ;Code for '9'

                cjne R6,#00H, next19
                Mov N1,#09H
                inc R6
                ret

next19:         cjne R6,#01H, next20
                Mov N2,#09H
                inc R6
                ret

next20:         cjne R6,#02H, next21
                Mov N3,#09H
                inc R6
                ret

next21:          cjne R6,#03H, $
                Mov N4,#09H
                RET

KeyCode11:      SETB F0                   ;Key found - set F0
                Mov R7,#'8'               ;Code for '8'

                cjne R6,#00H, next22
```

```
                        Mov N1,#08H
                        inc R6
                        ret

next22:                 cjne R6,#01H, next23
                        Mov N2,#08H
                        inc R6
                        ret

next23:                 cjne R6,#02H, next24
                        Mov N3,#08H
                        inc R6
                        ret

next24:                 cjne R6,#03H, $
                        Mov N4,#08H
                        RET

KeyCode21:              SETB F0                     ;Key found - set F0
                        Mov R7,#'7'                 ;Code for '7'

                        cjne R6,#00H, next25
                        Mov N1,#07H
                        inc R6
                        ret

next25:                 cjne R6,#01H, next26
                        Mov N2,#07H
                        inc R6
                        ret

next26:                 cjne R6,#02H, next27
                        Mov N3,#07H
                        inc R6
                        ret

next27:                 cjne R6,#03H, $
                        Mov N4,#07H
                        RET

IDCode3:                JNB P0.4, KeyCode00         ;If Col0 Row0 is cleared - key found
                        JNB P0.5, KeyCode10         ;If Col1 Row0 is cleared - key found
                        JNB P0.6, KeyCode20         ;If Col2 Row0 is cleared - key found
                        RET


KeyCode00:              SETB F0                     ; Key found - set F0
                        Mov R7,#'='                 ; Code for '#'
                        Clr A
                        Mov A,R7
                        Call SendChar
```

```
;--------------------------------- R4 stores the number of times the key '*' is pressed-------------------------------;

cjne R4,#01H, OP2                       ; If R4=1, jump to ADDITION subroutine
Call ADDITION

OP2:
cjne R4,#02H, OP3                       ; If R4=2, jump to SUBTRACTION subroutine
Call SUBTRACTION

OP3:
cjne R4,#03H, OP4                       ; If R4=3, jump to MULTIPLICATION subroutine
Call MULTIPLICATION

OP4:
Call DIVISION                           ; Jump to DIVISION subroutine
RET

KeyCode10:          SETB F0                   ;Key found - set F0
                    Mov R7,#'0'               ;Code for '0'

                    cjne R6,#00H, next28
                    Mov N1,#00H
                    inc R6
                    Ret

next28:             cjne R6,#01H, next29
                    Mov N2,#00H
                    inc R6
                    Ret

next29:             cjne R6,#02H, next30
                    Mov N3,#00H
                    inc R6
                    Ret

next30:             cjne R6,#03H, $
                    Mov N4,#00H
                    RET

KeyCode20:          SETB F0                   ;Key found - set F0
                    Mov R7,#'*'               ;Code for '*'

                    inc R4
                    RET
```

INTERFACING THE LCD MODULE WITH 8051 MICROCONTROLLER

The interface of the LCD module and 8051 microcontrollers is shown in the diagram below:



The assembly language codes behind the working of the LCD is being discussed below:

```
;----------------------------- *Code for LCD* ------------------------------;

FuncSet:        ; Function set (for interfacing lcd in 4-bit mode)
                ; P1.4 - P 1.7 controls both DB0-DB3 and DB4-DB7
Clr  P1.7
Clr  P1.6
SetB P1.5
Clr  P1.4       ; (DB4)DL = 0 -> puts LCD module into 4-bit mode.
```

```
Call Pulse      ; negative edge on E, the module reads the data lines
                  DB7 - DB4

Call Delay      ; wait for BF (busy flag) to clear

Call Pulse      ; negative edge on E

SetB P1.7       ; P1.7=1 (N=1) -> turns on 2 lines of display
Clr  P1.6       ; P1.6=0 (F=0) -> font set to 5 x 8 dots
Clr  P1.5
Clr  P1.4

Call Pulse

Call Delay
Ret

;---------------------------- Display on/off control -------------------------;

DispCon:        ; The display and cursor are turned on
Clr P1.7        ; high nibble set
Clr P1.6        ;|
Clr P1.5        ;|
Clr P1.4        ;|

Call Pulse
                        ; lower nibble set
SetB P1.7               ;
SetB P1.6               ; Sets entire display ON
SetB P1.5               ; Cursor ON
SetB P1.4               ; Cursor blinking ON
Call Pulse

Call Delay              ; wait for BF to clear
Ret
```

```
;-------------------------- Entry mode set (4-bit mode) ----------------------;
;--------------Set to increment the DDRAM address by one and cursor
shifted to the right------------;

EntryMode:
Clr P1.7          ;| high nibble set
Clr P1.6          ;|
Clr P1.5          ;|
Clr P1.4          ;|

Call Pulse
                  ; lower nibble set
Clr  P1.7         ; P1.7 = '0'
SetB P1.6         ; P1.6 = '1'
SetB P1.5         ; P1.5 = '1' ; I/D=1 -> Increment ; I/D=0 -> Decrement
Clr  P1.4         ; P1.4 = '0'

Call Pulse

Call Delay        ; wait for BF to clear
Ret



;---------------------------------- SendChar ----------------------------------;
;Display the key that is pressed------------;

SendChar:         Mov C, ACC.7            ; |     high nibble set
                  Mov P1.7, C             ; |
                  Mov C, ACC.6            ; |
                  Mov P1.6, C             ; |
                  Mov C, ACC.5            ; |
                  Mov P1.5, C             ; |
                  Mov C, ACC.4            ; |
                  Mov P1.4, C             ; |
Call Pulse

Mov C, ACC.3            ; |   low nibble set
Mov P1.7, C             ; |
Mov C, ACC.2            ; |
Mov P1.6, C             ; |
Mov C, ACC.1            ; |
Mov P1.5, C             ; |
Mov C, ACC.0            ; |
Mov P1.4, C             ; |

Call Pulse

Call Delay              ; wait for BF to clear

Ret

;------------------------------Pulse subroutine -------------------------------;

Pulse:
SetB E    ; P1.2 is connected to 'E' pin of LCD module
Clr  E    ; i.e. The LCD module will read the data lines (DB7-DB4)
Ret       ; on the falling edge of the signal



;------------------------------- Delay Subroutine ----------------------------;

Delay:    Mov R0, #50
          Djnz R0, $
          Ret
```

CODE FOR MATHEMATICAL CALCULATION.

- Finally we come to the main part of Designing where we intend to use the calculator.
- The assembly language code for the various operations is shown below-

```
ADDITION:    Mov A,R3
             Add A,R5
             Call ResultBits      ; Extracting two digits from the final result
             Call Ascii1          ; Converts the 1st HEX digit into ASCII
             Call Ascii2          ; Converts the 2nd HEX digit into ASCII

              jmp $

SUBTRACTION:  Mov A,R3           ;Code for subtraction
               Subb A,R5
               Jc Negative       ;jump if result of calculation is negative
               Call Positive

Positive:     Call ResultBits    ;printing for positive result
              Call Ascii1
              Call Ascii2
              jmp $

Negative:     Mov R7,#'-'        ;for displaying -ve character
              Clr A
              Mov A,R7
              Call SendChar
              Clr A
              Mov A,R5           ;calculating sub result in case of -ve
              Subb A,R3
              Inc A
              Call ResultBits    ;displaying -ve result
              Call Ascii1
              Call Ascii2
              jmp $

MULTIPLICATION:    Mov A,R3      ;code for multiplication
                   Mov B,R5
```

```
                        Mul AB
                        Call ResultBits   ;displaying results
                        Call Ascii1
                        Call Ascii2

                        jmp $

DIVISION:               Mov A,R3          ;code for divison
                        Mov B,R5
                        Div AB
                        Call ResultBits   ;displaying results
                        Call Ascii1
                        Call Ascii2

                        jmp $

;--------------- Extracting two digits from the calculation result ---------------;


ResultBits:   mov N5,A              ;moves result to N5
              mov B,#0AH
              Div AB
              Mov N6,A              ;moves quotient of result to N6
              Mov N7,B              ;moves remainder of result to N7
              ret
```

- Since the result obtained from our calculator is in Hexadecimal form so we need to convert it to ASCII Form for the LCD display.

```
Ascii1 :      MOV A, N6             ; Store first digit into A
              CLR C
              SUBB A, #0AH          ; Check if digit is greater than 10
              MOV A, N6
              JC SKIP1
              ADD A, #07H            ; Add 07 if >09
              Call SendChar

              ret

SKIP1:        ADD A, #30H           ; Else add only 30h for 0-9
              Call SendChar
```

```
Ascii2 :    MOV A, N7              ; Store second digit into A
            CLR C
            SUBB A, #0AH           ; Check if digit is greater than 10
            MOV A, N7
            JC SKIP2
            ADD A, #07H             ; Add 07 if number is >09
            Call SendChar

            ret

SKIP2:      ADD A, #30H            ; Else add only 30h for 0-9
            Call SendChar

            End
```

LIMITATIONS OF OUR PROJECT

There are certain limitations in our project:

Firstly, we are restricted to only 8-bit operations.

Secondly, the results displayed are only integral values and no fractional result is displayed or any fractional data cannot be provided as input.

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- https://www.edsim51.com/simInstructions.html#lcdModule