Embedded System Training

MSME

MICRO, SMALL & MEDIUM ENTERPRISES
सूक्ष्म, लघु एवं मध्यम उद्यम
OUR STRENGTH • हमारी शक्ति

Ministry of MSME, Govt. of India

SRM
INSTITUTE OF SCIENCE & TECHNOLOGY

INTRODUCTION.

- The objectives of MSME-DI, Agra, are to provide Technical Consultancy Services to the entrepreneurs in addition to Industrial Management Trainings, Entrepreneurs Development Programmes, Short Term Management Trainings for Micro, Small & Medium Entrepreneurs, Industrial Motivational Campaigns, Implementation and Monitoring of PMEGP Scheme, Entrepreneurship & Skilled Development Programmes, Establishing of Sub Contracting Exchange, Awareness on Energy Conservation, Quality Control & its up gradation and Ancillary Development. The Institute also provides Market Information, Industrial Potential Survey Report, Statistical Information, Identification of Thrust Industries, Export Promotion, Directory of MSMEs , Economic Information to set up MSMEs.

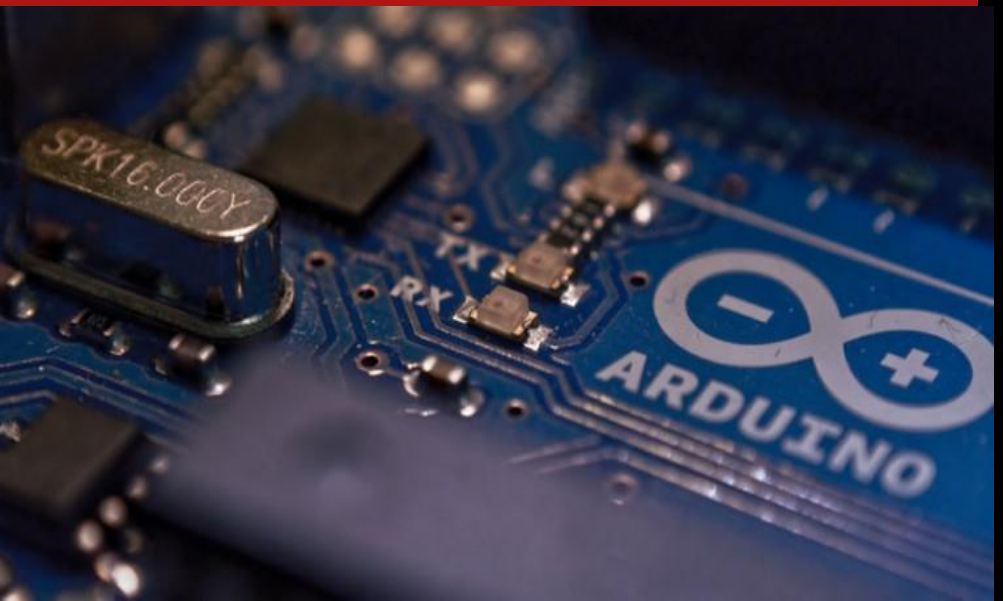
CONTENT

- Arduino Programming
- Proteus Designing
- Embedded C in Keil
- 8051, ARM
- Projects on Microcontroller

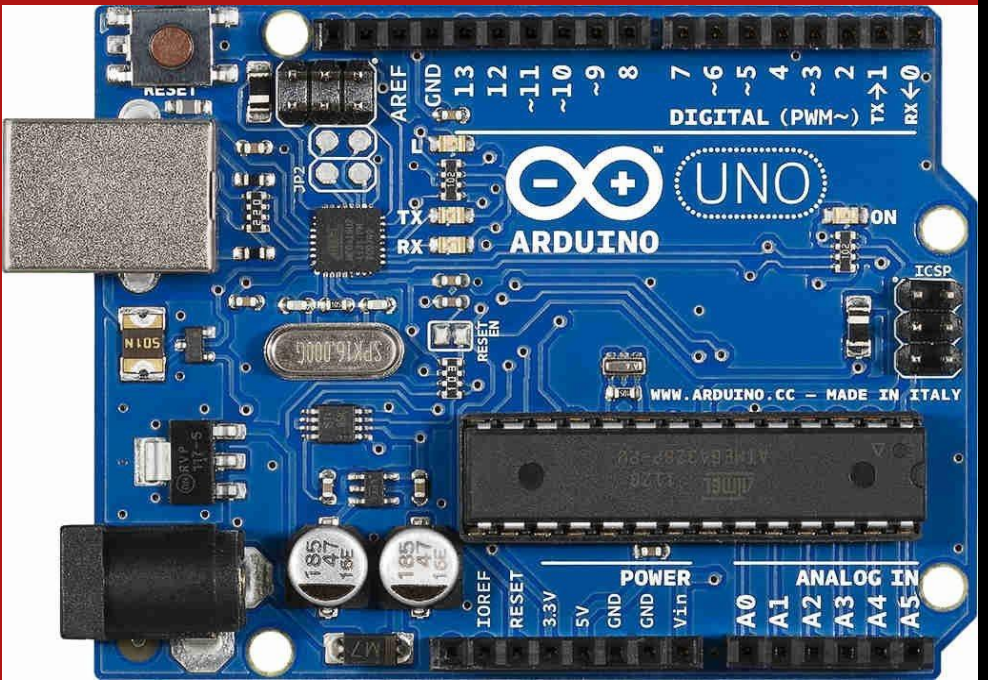
ARDUINO

- A small computer on a single chip containing a processor, memory, and input/output. Typically "embedded" inside some device that they control. A microcontroller is often small and low cost
- Development board-A printed circuit board designed to facilitate work with a particular microcontroller.

  Typical components include-
- power circuit
- programming interface
- basic input; usually buttons and LEDs
- I/O pins



WHAT IS THE AURDINO?



- Arduino provides open-source electronics prototyping platforms based on flexible, easy-to-use hardware and software. Arduino prototyping platforms are intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments. Arduino's prototyping platforms can sense the environment by receiving input from a variety of sensors and can affect their surroundings by controlling lights, motors, and other actuators. Arduino projects can be stand-alone or they can communicate with software running on a computer.

LETS GET STARTED!

- Download & install the Arduino environment (IDE)
- Connect the board to your computer via the UBS.
- Cable.
- If needed, install the drivers (not needed in lab).
- Launch the Arduino IDE
- Select your board.
- Select your serial port.
- Open the blink example.
- Upload the program.

A Little Bit About Programming

- Functions

For controlling the Arduino board and performing computations.

- **Digital I/O**

digitalRead()
digitalWrite()
pinMode()

- **Analog I/O**

analogRead() ,

analogReference()
analogWrite()

- **Zero, Due & MKR Family**

analogReadResolution()
analogWriteResolution()

- **Advanced I/O**

noTone()
pulseIn()
pulseInLong()
shiftIn()
shiftOut()
tone()

- **Time**

delay()
delayMicroseconds()
micros()
millis()

A Little Bit About Programming

- Functions

  For controlling the Arduino board and performing computations.

- **Math**

abs()
constrain()
map()
max()
min()
pow()
sq()
sqrt()

- **Trigonometry**

cos()
sin()
tan()

- **Characters**

isAlpha()
isAlphaNumeric()
isAscii()
isControl()
isDigit()
isGraph()
isHexadecimalDigit()
isLowerCase()
isPrintable()
isPunct()
isSpace()
isUpperCase()
isWhitespace()

A Little Bit About Programming

- Functions

For controlling the Arduino board and performing computations.

- **Random Numbers**
- random()
  randomSeed()

- **Bits and Bytes**
- bit()
  bitClear()
  bitRead()
  bitSet()
  bitWrite()
  highByte()
  lowByte()

- **External Interrupts**
- attachInterrupt()
  detachInterrupt()

- **Interrupts**
- interrupts()
  noInterrupts()

- **Communication**
- Serial
  Stream

- **USB**
- Keyboard
  Mouse

A Little Bit About Programming

- Variables

Arduino data types and constants.

- **Constants**
- HIGH | LOW
  INPUT | OUTPUT | INPUT_PULLUP
  LED_BUILTIN
  true | false
  Floating Point Constants
  Integer Constants

- **Conversion**
- (unsigned int)
  (unsigned long)
  byte()
  char()
  float()
  int()
  long()
  word()

- **Variable Scope & Qualifiers**
- const
  scope
  static
  volatile

- **Utilities**
- PROGMEM
  sizeof()

A
Little
Bit
About
Programming

- Variables

Arduino data types and constants.

- **Data Types**

- array
  bool
  boolean
  byte
  char
  double
  float
  int
  long
  short
  size_t
  string
  String()
  unsigned char
  unsigned int
  unsigned long
  void
  word

A Little Bit About Programming

- Structure

The elements of Arduino (C++) code.

Sketch

loop()
setup()

Control Structure

break
continue
do...while
else
for
goto
if
return
switch...case
while

Further Syntax

#define (define)
#include (include)
/* */ (block comment)
// (single line comment)
; (semicolon)
{} (curly braces)

millis()

A
Little
Bit
About
Programming

- Structure

The elements of Arduino (C++) code.

Arithmetic Operators

% (remainder)
* (multiplication)
+ (addition)
- (subtraction)
/ (division)
= (assignment operator)

Comparison Operators

!= (not equal to)
< (less than)
<= (less than or equal to)
== (equal to)
> (greater than)
>= (greater than or equal to)

Boolean Operators

! (logical not)
&& (logical and)
|| (logical or)

A Little Bit About Programming

- Structure

The elements of Arduino (C++) code.

Pointer Access Operators

& (reference operator)
* (dereference operator)

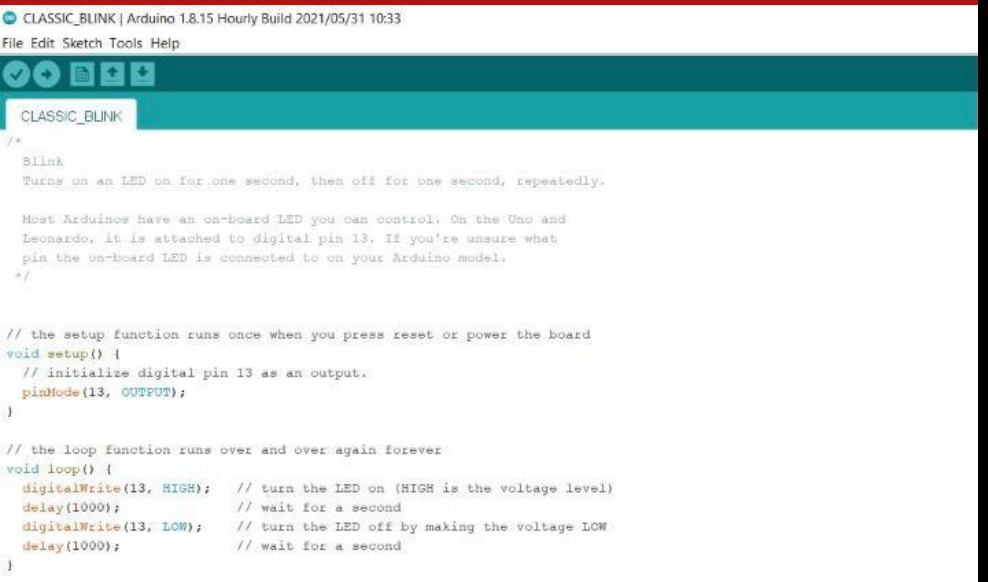
Bitwise Operators

& (bitwise and)
<< (bitshift left)
>> (bitshift right)
^ (bitwise xor)
| (bitwise or)
~ (bitwise not)

Compound Operators

%= (compound remainder)
&= (compound bitwise and)
*= (compound multiplication)
++ (increment)
+= (compound addition)
-- (decrement)
-= (compound subtraction)
/= (compound division)
^= (compound bitwise xor)
|= (compound bitwise or)

OUR FIRST PROGRAM




```
  Turns on an LED on for one second, then off for one
second, repeatedly.


  Most Arduinos have an on-board LED you can control. On the
Uno and

  Leonardo, it is attached to digital pin 13. If you're
unsure what

  pin the on-board LED is connected to on your Arduino
model, check

 */



// the setup function runs once when you press reset or
power the board

void setup() {

  // initialize digital pin 13 as an output.

  pinMode(13, OUTPUT);

}


// the loop function runs over and over again forever

void loop() {

  digitalWrite(13, HIGH);   // turn the LED on (HIGH is the
voltage level)

  delay(1000);              // wait for a second

  digitalWrite(13, LOW);    // turn the LED off by making
```

TERMINOLOGY

- "Sketch"-A program which we can write to run it on an Aurdino Board.
- "pin"-An input or output connected to something (example-LED, input from a nob)
- "digital"-Value is either high or low (aka on/off, one/zero) switch state.
- "analog"-value ranges usually from 0-255(example– LED Brightness, motor speed.)

DIGITAL?

ANALOG?

- Digital has two values: on and off
- Analog has many (infinite) values
- Computers don't really do analog, they quantize
- We should always remember the 6 analog input pins---voltage, analog signal, digital point , digital signal, sampled point, time.

DIGITAL I/0

- pinMode(pin, mode)

Sets pin to either INPUT or OUTPUT

- digitalRead(pin)

Reads HIGH or LOW from a pin

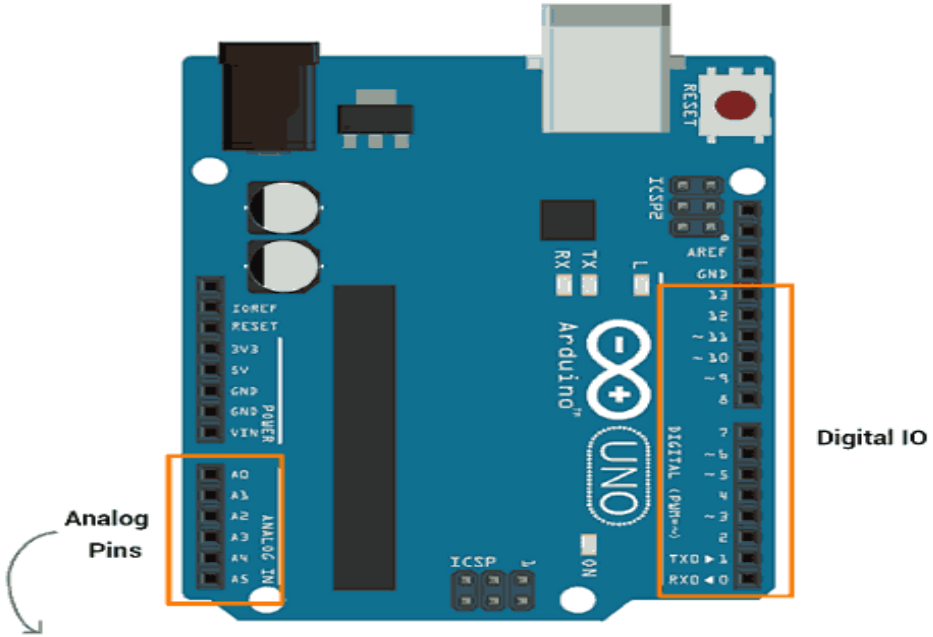
- digitalWrite(pin, value)

Writes HIGH or LOW to a pin

- Electronic stuff

Output pins can provide 40 mA of current

Writing HIGH to an input pin installs a 20KΩ pullup

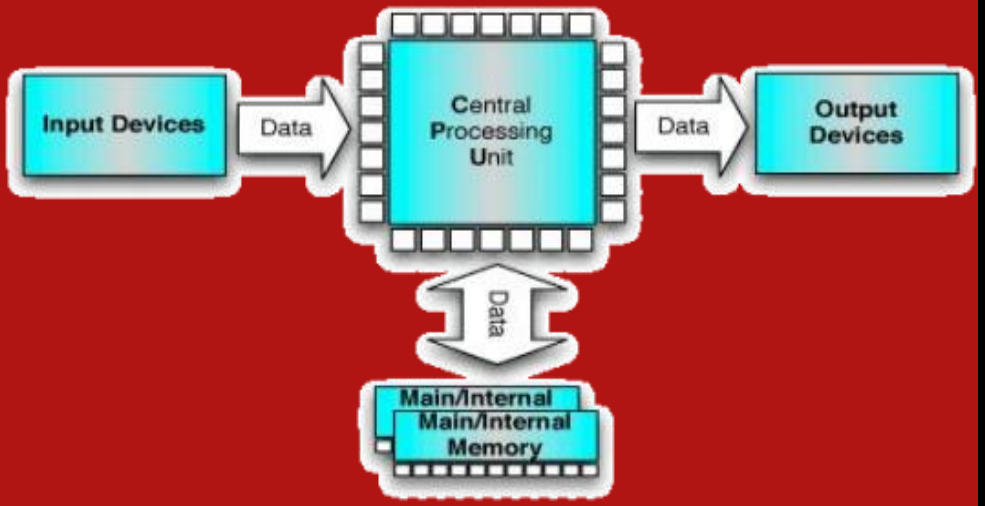


COMPUTER SYSTEM

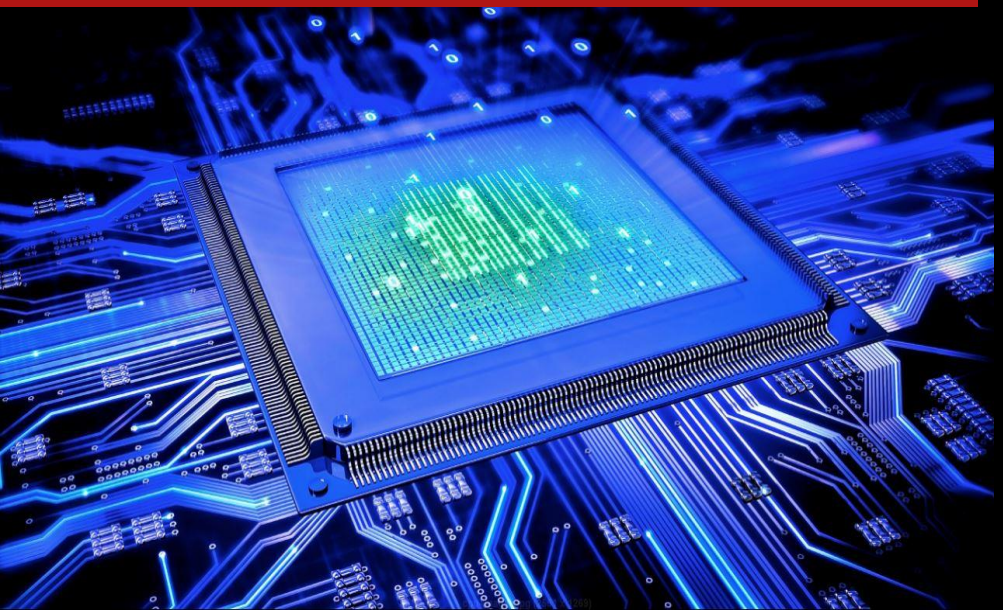
- A Computer system is a programmable machine that receive input ,stores and manipulate data/ information and provide output.

BLOCK DIGRAM

- Basic computer system consist of Central Processing Unit (CPU), Memory (RAM and ROM), input / output (I/O) Unit.



CENTRAL PROCESSING UNIT



- The portion of a computer system that carries out the instruction of a computer program.
- The primary element carrying out the computer's function .It is the unit that reads and executes program instructions.
- The data in the instruction tells the processor what to do.

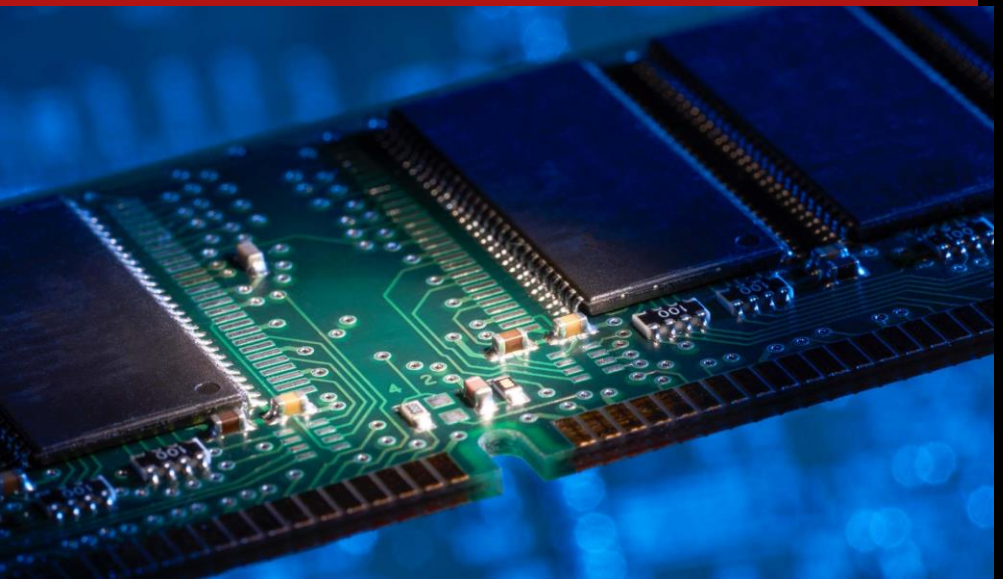
MEMORY

- Physical device used to store data or Program on a temporary or permanent basis for use in an electronic digital computer .
- Computer main memory comes in to principles variation..

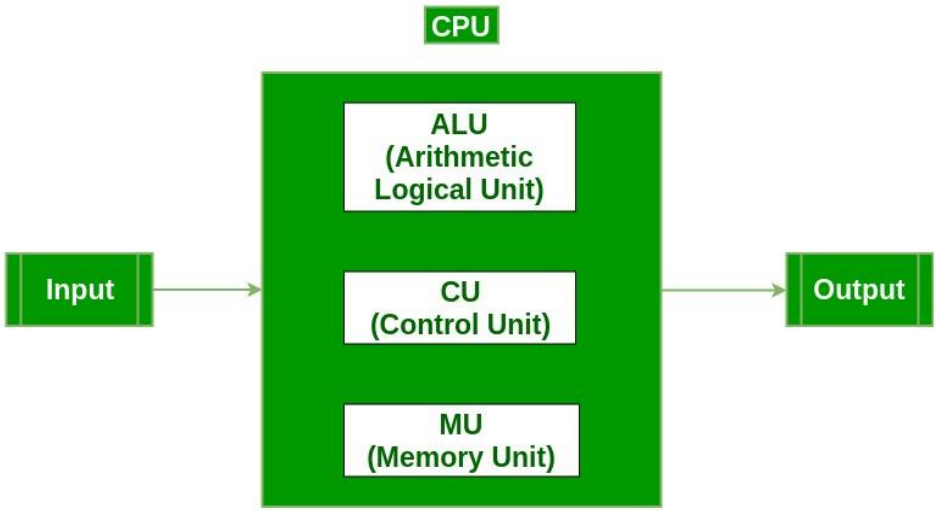
(1) Random Access Memory (RAM)

(2) Read Only Memory (ROM).

- RAM can be read and write to anytime the CPU command's it , but ROM is preloaded with data and software that never changes, so the CPU can only read from it..
- RAM is typically use to stored the computer's initial start up instruction.
- In general , the computers of RAM are erased when power to the computers is turned off, but ROM retains its data after turned off computer.



INPUT/OUTPUT UNIT



- Input /Output (I/O) , refers to the communication between an information processing system (such as computer) and outside world possibly a human or another information processing system.
- Inputs are the signal or data received by the system and Output are the signal or data sent from it. Device that provides input or Outputs to the computers are called Peripherals.

DATA SIZE

- BIT = 1 or 0
- NIBBLE = 4 BIT
- BYTE = 8 BIT
- WORD = 16 BIT
- LONG WORD = 32 BIT

EMBEDDED SYSTEM

- Special-purpose computer system designed to perform a dedicated function.
- Performs one or a few pre-defined tasks, usually with very specific requirements, and often includes task-specific hardware and mechanical parts not usually found in a general-purpose computer.

COMPONENTS OF EMBEDDED SYSTEM

- **Analog Components**
  Sensors (LDR,LM35 etc.)
- **Digital Components**
  Processor, Coprocessors
  Memories
- Controllers, Buses
  Application Specific Integrated Circuits
- **Converters –** A2D, D2A.
- **Software**
  Application Programs

- EMBEDDED DESIGNING

1. Core hardware
2. Firmware tools
3. Programming tools
4. Hardware tools

DESIGNING

- Core hardware
  - 8051 Microcontroller
  - PIC (Peripheral Interface Control) Microcontroller
  - AVR Microcontroller
  - ARM (Advance risk machine) Microcontroller
  - FPGA(Field Programmable Gate Array)
  - CPLD(Complex Programmable Logic Device)
- **Firmware tools**
  - **8051-** KEIL Compiler & Assembler
  - **PIC -** Source Boost , micro c
  - **AVR –** Code Vision Avr
  - **ARM** - KEIL advanced versions
- **Programming tools**
  - **8051** – Flash Magic , ECE Flash
  - **PIC** - Matrix pppv3 , pickit
  - **AVR** – Pony Prog
  - **ARM** – Flash Utility
- **Hardware tools**
  - Hardware programmers
  - Application debuggers

EMBEDDED APPLICATIONS

- **AUTOMOBILES**: Fuel Injection control (for fuel efficiency), Air bags and Automatic braking (for safety), and car entertainment systems.
- **MEDICAL ELECTRONICS:** Many sophisticated medical instruments (Body Scanners, Heart rate monitors, Pacemaker etc) Industrial Control: such as CNC machines are example embedded systems.
- **BUSINESS APPLICATIONS:** Vending machines, scanners, printers.
- **CONSUMER ELECTRONICS:** Cameras, Toys, Cellular Phones, Washing Machines
- **AVIONICS**: Airplanes, Satellite Stations
- **Defense:** RADARs, SONARs (for surveillance), Guided Missile Systems

MICROCOMPUTERS

- MICROPROCESSOR :-

Microprocessor is not a complete microcomputer its contain only processing unit .

A microprocessor is a single chip semi conductor device also which is a computer on chip, but not a complete computer.

Its CPU contains an ALU, a program counter, a stack pointer, some working register, a clock timing circuit and interrupt circuit on a single chip.

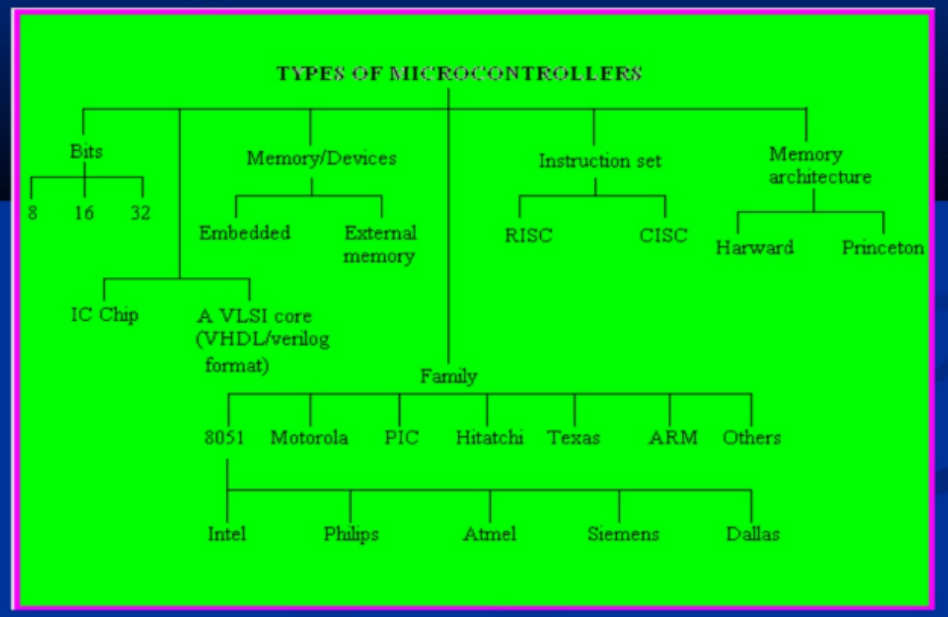
To make complete micro computer, one must add memory usually ROM and RAM, memory decoder, an oscillator and a number of serial and parallel ports.

- MICROCONTROLLER

A microcontroller is a functional computer system-on-a-chip. It contains a processor, memory, and programmable input/output peripherals.

Microcontrollers include an integrated CPU, memory (a small amount of RAM, program memory, or both) and peripherals capable of input and output.

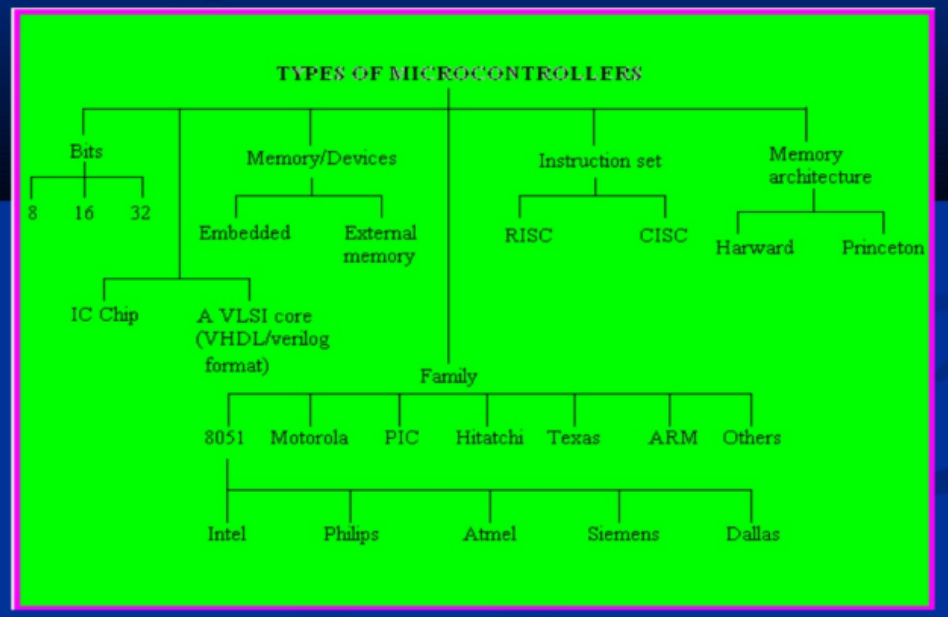
CLASSIFICATION OF MICROCONTRLLER



- **Classification According to Number of Bits**
- In **8-bit** microcontroller, the point when the internal bus is 8-bit then the ALU is performs the arithmetic and logic operations. The examples of 8-bit microcontrollers are Intel 8031/8051.
- The **16-bit** microcontroller performs greater precision and performance as compared to 8-bit. 16 bit microcontroller can proceed data up to 16 bit .
- The **32-bit** microcontroller uses the 32-bit instructions to perform the arithmetic and logic operations.
- Ex-ARM7
- **Classification According to Memory Devices**
- **Embedded memory microcontroller**: When an embedded system has a microcontroller unit that has all the functional blocks available on a chip is called an embedded microcontroller. For example, 8051 having program & data memory, I/O ports, serial communication, counters and timers and interrupts on the chip is an embedded microcontroller.
- **External Memory Microcontroller**: When an embedded system has a microcontroller unit that has not all the functional blocks available on a chip is called an external memory microcontroller. For example, 8031 has no program memory on the chip is an external memory microcontroller.
- **Classification According to Instruction Set**
- **CISC**: CISC is a Complex Instruction Set Computer. It allows the programmer to use one instruction in place of many simpler instructions.
- **RISC**: The RISC is stands for Reduced Instruction set Computer, this type of instruction sets reduces the design of microprocessor for industry standards. It allows each instruction to operate on any register or use any addressing mode and simultaneous access of program and data.
-

CLASSIFICATION OF MICROCONTRLLER

Types of Microcontrollers



- **Classification According to**
- **Memory Architecture**
- **Harvard Memory Architecture Microcontroller**: The point when a microcontroller unit has a dissimilar memory address space for the program and data memory, the microcontroller has Harvard memory architecture in the processor.
- **Princeton Memory Architecture Microcontroller**: The point when a microcontroller has a common memory address for the program memory and data memory, the microcontroller has Princeton memory architecture in the processor.
- CRITERIA FOR CHOOSING MICROCONTROLLER

1.The first and most criteria in choosing a microcontroller is that it must meet the task and cost effective.

2.In analysing the need of microcontroller base project we first see whether an 8 bit , 16 bit , 32 bit Microcontroller can be best handle the computing need.

3.Speed (what is the highest speed that microcontroller support).

4. Power Consumption:- This is specially criteria for battery power product.

5.The amount of RAM and ROM in chip.

6.The no. of I/O pins and the timer on the chip. ● 7.How easily it is to upgrade to high performance.. ● Cost per unit :- This is important in term of final cost of the product in which a microcontroller is used.

- INTODUCTION TO MICROCONTROLLER

In 1981 intel corporation introduced an 8 bit microcontroller called 8051. The microcontroller had 128 byte of RAM ,4 kb of ROM on chip, 2 Timers, one serial port and four ports (each 8 bit) on a single chip at the time it will also referred as system on chip. The 8051 this is an 8 bit microcontroller , means CPU can work on only 8 bit at a time .

- Data larger than 8 bit as to broken into 8 bit piece to be processed by CPU.

The 8051 has total of four I/O ports each of 8 bits. Although the 8051 can have a maximum of [illegible] kilobytes of on chip ROM, many manufacturer have put only 4 k byte on chip. The 8051 became very popular after intel allowed other manufacturer to make an market any flavour of 8051.

8051 Family Members

- ROM type

8031 no ROM

80xx mask ROM

87xx EPROM

89xx Flash EEPROM

89xx

8951

8952

8953

8955

898252

891051

892051

- Example (AT89C51,AT89LV51)

AT= ATMEL(Manufacture)

C = CMOS technology

LV = Low Power(3.0v)

Comparison some of the 8051 Family Members

- ROM RAM Timer

- 8051 -4k 128 2. 8031 - 128 2. 8751 4k eprom 128 2.

8052 8k rom 256 3. 8032 - 256 3.

8752 8k eprom 256 3.

8051 Basic Component

- 4K bytes internal ROM
- 128 bytes internal RAM
- Four 8-bit I/O ports (P0 - P3).
- Two 16-bit timers/counters
- One serial interface
- 64k external memory for code
- 64k external memory for data
- 210 bit addressable

- The basic 8051 Core

8-bit CPU optimized for control applications

Capability for single bit Boolean operations.

Supports up to 64K of program memory.

Supports up to 64K of data memory.

4 K bytes of on-chip program memory.

Newer devices provide more.

128 bytes of on-chip data RAM

Four 8 bit ports.

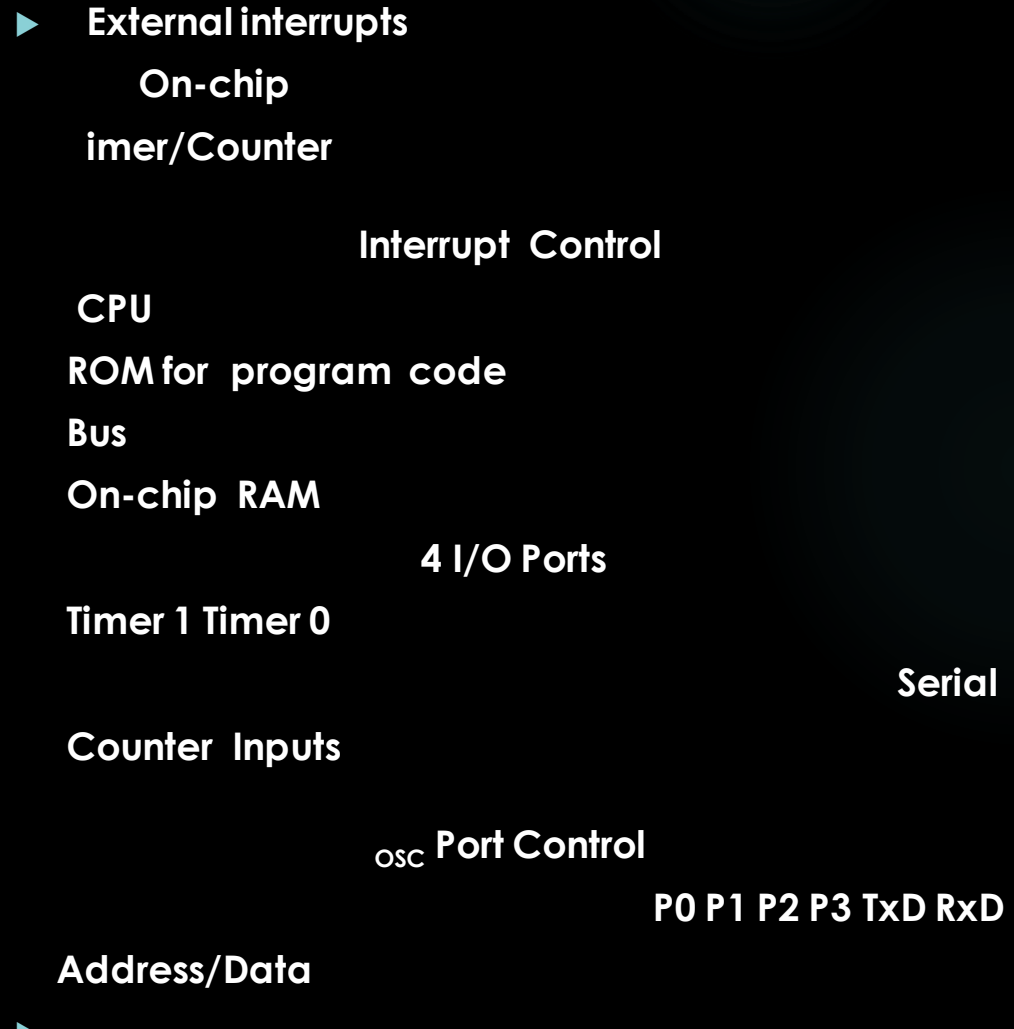
Two 16-bit timer/counters

UART

Interrupts

On-chip clock oscillator

Block Diagram



Special Function Registers (SFR)

Special function registers are part of RAM memory. Their purpose is predefined by the manufacturer and cannot be changed therefore.

Since their bits are physically connected to particular circuits within the microcontroller, such as A/D converter, serial communication module etc.

Any change of their state directly affects the operation of the microcontroller or some of the circuits.

- **Program Counter**

Program Counter is an engine running the program and points to the memory address containing the next instruction to execute.

After each instruction execution, the value of the counter is incremented by 1.

For this reason, the program executes only one instruction at a time.

However…the value of the program counter can be changed at any moment, which causes a "jump" to a new memory location.

After jumping, the counter resumes even and monotonous automatic counting +1, +1, +1…

Central Processor Unit (CPU)

- As its name suggests, this is a unit which monitors and controls all processes within the microcontroller and the user cannot affect its work.
- ***Instruction decoder*** :-

Is a part of the electronics which recognizes

program instructions and runs other circuits on the basis of that.

The abilities of this circuit are expressed in the

"instruction set" which is different for each

microcontroller family

- ***Arithmetical Logical Unit (ALU)*** :- **P**erforms all mathematical and logical operations upon data.
- ***Accumulator*** is an SFR closely related to the operation of ALU. It is a kind of working desk used for storing all data upon which some operations should be executed . It also stores the results ready for use in further processing.

Memory Organization

- 8051 Memory Organization
- **The total memory of 8051 is logically divided into**

1) Program

Memory

2) Data Memory

1) Program

Memory

The 8051 has 4k byte of internal program memory (on chip memory-ROM) Which starts from 0000H to 0FFFH .The address of memory location is 16 bit and normally stored in program counter to fetch instruction from memory. It is used to store program only not data.

The program memory of 8051 can be increased by Interfacing 64KB of external memory ROM i.e. program which address starts From 0000H to FFFFH.

2.Data

Memory

It is used for temporary storage of data .It is divided into-

1) Internal data memory

2) External data memory

Internal data memory

It is consist of two part the first is the RAM block of 128 bytes & second is set of address from 80H to FFH. Which is used for special function registers.

External data

memory

- **The external RAM of 64KB can be connected.**

Pin out Description

- **Pins 1-8 :** Port 1 Each of these pins can be configured as an input or an output.
- **Pin 9 :** RSA logic one on this pin disables the microcontroller and clears the contents of most registers. In other words, the positive voltage on this pin resets the microcontroller. By applying logic zero to this pin, the program starts execution from the beginning.
- **Pins 10-17:** Port 3 Similar to port 1, each of these pins can serve as general input or output. Besides, all of them have alternative functions:
- 22-03-2016 37
- **Pin 10:** RXD Serial asynchronous communication input or Serial synchronous communication output.
- **Pin 11:** TXD Serial asynchronous communication output or Serial synchronous communication clock output.
- **Pin 12:** INT0 Interrupt 0
- input.
- **Pin 13:** INT1 Interrupt 1
- input.
- **Pin 14:** T0 Counter 0 clock
- input.
- **Pin 15:** T1 Counter 1 clock
- **Pin 16:** Write to external (additional)
- RAM.

Pin out Description

- **Pin 17:** RD Read from external RAM
- **Pin 18, 19:** X2, X1 Internal oscillator input .
- A quartz crystal which specifies operating frequency is usually connected to these pins.
- **Pin 20:** GND Ground.
- **Pin 21-28:** Port 2 If there is no intention to use external memory then These port pins are configured as general inputs/outputs. In case external memory is used, the higher address byte, i.e. addresses A8-A15 will appear on this port.
- **Pin 29: PSEN (program store enable)** If external ROM is used for storing program every time the microcontroller reads a byte from memory.
- It is a program store enable Pin whenever device is executing code from external program memory PSEN is active (logic 0). It is used to fetch the code from external memory .
- For internal program memory this pin should be inactive(logic 1 or high).
- **Pin 30: ALE** (Address latch enable) 8051 port -0 provides both address & data. So we have to make separate .
- The ALE pin is used for de-multiplexing the address &data by connecting to the G pin (enable pin) of the 74LS373 latch IC. When ALE=0 data path is selected & when ALE=1 address path is selected.
- **Pin 31: EA** It is stand for external access . It is an input pin and must be connected to either Vcc or Ground.
- By applying logic zero (ground) to this pin, P2 and P0 are used for data and address transmission.
- By connecting Vcc to indicate that the program code is stored in the microcontroller's on chip ROM.

External data memory

Pin 32-39: Port 0 Similar to P2, if external memory is not used, these pins can be used as general inputs/outputs. Otherwise, P0 is configured as address output (A0-A7) when the ALE pin is driven high (1) or as data output (Data Bus) when the ALE pin is driven low (0).

Pin 40: VCC +5V power

supply.

Pull-Up Resistors

- Port 0 as both input and output port A each pin must connected externally to a 10k-ohm pull up register. This is due to the fact that p0 is an open drain .

Register B

It is used to store 8 bit data. It is a special function register.

Register B is used with accumulator for multiplication and division.

Rn Register

- This is common name for the total 8 general purpose registers (R0, R1, R2,…..R7).

They are not true SFR similar to Accumulator they are used for temporary storing variable/ value and intermediate result .

These registers are stored in four bank.

DPTR

Data Pointer Register

- It is a 16 bit registers but it is divided into two registers named DPH & DPL.
- DPTR does not have a single internal address it can be used as 16 –bit register or as two independent 8 bit register.
- The DPTR is used to furnish memory address and external data access.

STACK

- The stack is a section of RAM used by the CPU to store information temporarily . This information could be data or an address. The CPU needs this storage area since there are only a limited number of register.

The Register used to access the stack is called the SP(stack pointer)

register. The stack pointer in the 8051 is only 8 bit wide which means

that it can take a value of 00 to FFH.

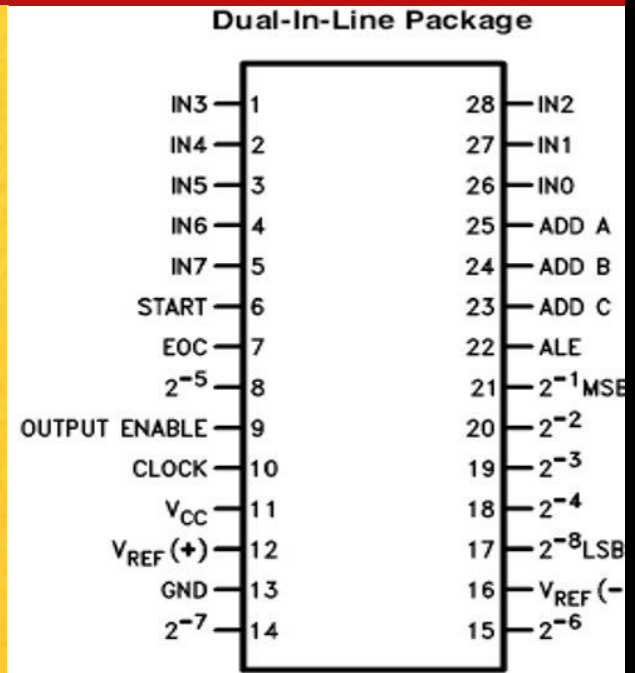
- Stack Pointer

It is a 8 bit register. It is used to hold an internal RAM address i.e. top of the stack.

It indicates the last byte push on the stack.

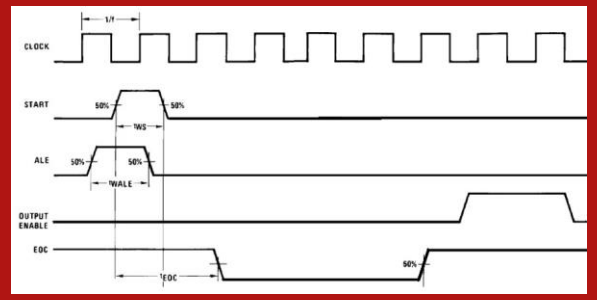
During stack write operation (push) on the stack pointer is first incremented by 1 & than save the data on to the stack. After resetting the mc the stack pointer is initialized with 07H address which cause the stack pointer to begin from location 08H.

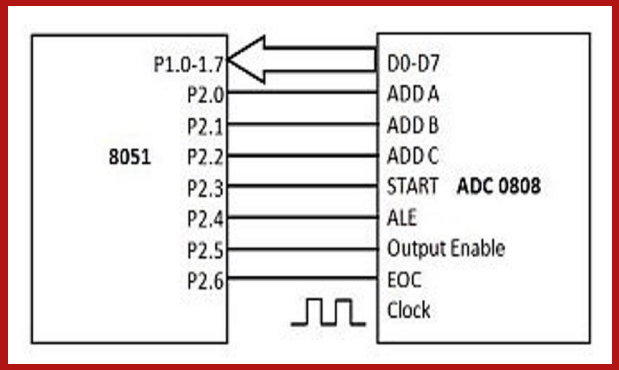
Analog To Digital converter (ADC)



- *An analog-to-digital converter is a device which converts continuous signals to discrete digital numbers. The reverse operation is performed by a digital-to-analog converter (DAC).*
- *Typically, an ADC is an electronic device that converts an input analog voltage (or current) to a digital number proportional to the magnitude of the voltage or current.*

Steps to interface 0809 ADC with 8051 uc





1. *Set initial values of SOC, EOC and OE.*
2. *Set ADD A, ADD B, ADD C.*
3. *High to low pulse on ALE.*
4. *High to low pulse on SOC with clock.*
5. *Monitor EOC bit.*
6. *Send h to l pulse to OE.*
7. *Read data.*
8. *Repeat the steps.*

- **Program to get data from ADC**

```
#include<reg51.h>
void main(void)
{
  SOC=0;
  OE=0;
  EOC=1;
  P2=0xff;
   while(1)
 {
sbit ALE=P1^2;
sbit SOC=P1^1;
sbit OE=P1^0;
sbit EOC=P1^3;
sbit SET0=P1^4;
sbit SET1=P1^5;
sbit SET2=P1^6;
sbit CLOCK=P1^7;
void clock(void);
void clock(void)
{
 int b;
 for(b=0;b<=30000;b++)
 CLOCK=~CLOCK;
 }

void delay(int x);
SET0=1;SET1=1;  SET2=1;       //for the select line
    ALE=1;    SOC=1;
    clock();
    SOC=0;   ALE=0;
    clock();
    while(EOC==0);
    OE=1;
    P3=P2;
     }
 }
```

Baud Rates in the 8051

- *The 8051 transfers and receives data serially at many different baud rates by using UART.*
- *UART divides the machine cycle frequency by 32 and sends it to Timer 1 to set the baud rate.*
- *Signal change for each roll over of timer*
- *Timer 1, mode 2 (8-bit, auto-reload)*
- *Define TH1 to set the baud rate.*
  - *XTAL = 11.0592 MHz*
  - *The system frequency = 11.0592 MHz / 12 = 921.6 kHz*
  - *Timer 1 has 921.6 kHz/ 32 = 28,800 Hz as source.*
  - *TH1=FDH means that UART sends a bit every 3 timer source.*
  - *Baud rate = 28,800/3= 9,600 Hz*

Registers regarding serial communication.

- **SCON Register**
- *Serial control register:* ***SCON***

  SM0, SM1 *Serial port mode specified*

  REN *(Receive enable) set/cleared by software to enable/disable reception.*

  TI *Transmit interrupt flag.*

  RI *Receive interrupt flag.*

  SM2 *=* ***TB8*** *=* ***TB8*** *=0 (not widely used)*

  SM0, SM1

- SM1 and SM0 determine the framing of data.
  - SCON.6 (SM1) and SCON.7 (SM0)
  - Only mode 1 is compatible with COM port of PC.

  TB8, RB8

TB8: The 9th data bit that will be transmitted in Modes 2 and 3. Set or clear by software as desired.

RB8: In modes 2 and 3, the 9th data bit that was received. In Mode 1, if SM2 = 0, RB8 is the stop bit that was received. In Mode 0, RB8 is not used.

REN (Receive Enable)

- SCON.4
- Set/cleared by software to enable/disable reception.
  - REN=1
    - If we want the 8051 to both transfer and receive data, REN must be set to 1.
  - REN=0
    - The receiver is **disabled.**
    - The 8051 can not receive data

Transfer Data with the TI flag

- The following sequence is the steps that the 8051 goes through in transmitting a character via TxD:
  1. The byte character to be transmitted is written into the SBUF register.
  2. It transfers the start bit.
  3. The 8-bit character is transferred one bit at a time.
  4. The stop bit is transferred.

Steps to transmit data from 8051 to pc

1.Load SCON register.
2.Laod TMOD register(select timer1 mode 2).
3. Load baud rate in TH1.
4. Start the timer.
5. Place character in SBUF.
6. Monitor TI flag.
7. Clear TI flag.

Program To Transmit Data To PC

```
#include<reg51.h>
unsigned char arr[]="Advance Technology";
void serial_init()
{
TMOD=0x20;
SCON=0x50;
TH1=0xfd;
TR1=1;
TI=0;
}
void serial_trans(unsigned char trans)
{
SBUF=trans;
while(TI==0);
TI=0;
}
void main ()
{
Int i;
serial_init();
   while(1)
   {
     for(i=0;i<=17;i++)
      {
serial_trans(arr[i]);
     }
}
```

Transfer Data with the TI flag

- Steps to Receive data from pc to 8051

1.Load SCON register.
2.Laod TMOD register(select timer1 mode 2).
3. Load baud rate in TH1.
4. Start the timer.
5. Monitor RI flag.
7. Read SBUF.
8. Clear RI.

Program to Received data form PC

```
#include<reg51.h>
void serial_init()
{
TMOD=0x20;
SCON=0x50;
TH1=0xfd;
TR1=1;
TI=0;
}
unsigned char serial_rec()
{
while(RI==0);
RI=0;
     return(SBUF);
}
void main ()
{
   serial_init();
    while(1)
    {
       P0=serial_rec();
    }
}
```

ROBOTICS

- "A robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks."
- Speed
- It can work hazardous/dangerous environment
- To perform repetitive task
- Efficiency
- Accuracy
- Adaptability

- Automation vs. Robots

Automation –Machinery designed to carry out a specific task

- Bottling machine
- Dishwasher
- Paint sprayer

Robots – machinery designed

- to carry out a variety of tasks
  - Pick and place arms
  - Mobile robots
  - Computer Numerical Control
  - machines

- Types of Robot
  - Wheeled
  - Legged
  - Climbing
  - Flying

Degrees of freedom

Control

- Open loop, i.e., no feedback, deterministic
- Closed loop, i.e., feedback, maybe a sense of touch and/or vision

Degrees of freedom

- Degrees of freedom—number of independent motions
  - Translation—3independent directions
  - Rotation-- 3 independent axes
  - 2D motion = 3 degrees of freedom: 2 translation, 1 rotation
  - 3D motion = 6 degrees of freedom: 3 translation, 3 rotation.

Types of motors used in robotics

- DC motors
  - DC non – geared motors
  - DC geared motors
- Stepper motors
- Servo motors

Interfacing of 8051 with DC Motors

DC Motors

- *The most common actuator in mobile robotics*
- *simple, cheap, and easy to use.*
- *come in a great variety of sizes, to accommodate different robots and tasks.*

As the name suggests, a motor which uses a DC (Direct Current) power, can run in both directions, speed Controllable.

Principles of Operation

- DC motors convert electrical into mechanical energy.
- They consist of permanent magnets and loops of wire inside.
- When current is applied, the wire loops generate a magnetic field, which reacts against the outside field of the static magnets.
- The interaction of the fields produces the movement of the shaft/armature.
- Thus, electromagnetic energy becomes motion.

DC Motor Working

- Direction of rotation controlled by polarity of current / voltage
- Speed of rotation controlled by average energy (power) fed to the motor

PWM

- Pulse width modulation is a technique for reducing the amount of power delivered to a DC motor.
- Instead of reducing the voltage operating the motor (which would reduce its power), the motor's power supply is rapidly switched on and off.
- The percentage of time that the power is on determines the percentage of full operating power that is accomplished.

▶ Program to run dc motor with PWM

```
#include<reg51.h>
#include<intrins.h>
sbit dc_motor = P0^0;
void delay(int num)
{
  int a,b;
  for(b=0; b<num; b++)
     for(a=0;a<=140;a++)
_nop_();
}
void PWM(unsigned char Ton)
{
dc_motor=1; //    motor ON
delay(Ton);
dc_motor=0; //     motor OFF
delay(100-Ton);
}
void main()
{
while(1)
        {
        PWM(50);
        }
}
```

Interfacing of 8051 with Stepper motor

- Stepper Motors
  - Used for measured rotation
  - Can be held at a particular position of the shaft
  - Ideal for many autonomous robots requiring higher precision
- Stepper Motor Working

Stepping Sequences for Single Coil Excitation

Only one coil is active at a given instant of time

Program to control the direction of stepper motor

```
#include<reg51.h>
sbit m1=P0^0;
sbit m2=P0^1;
sbit m3=P0^2;
sbit m4=P0^3;
void delay(unsigned int x)
{
unsigned int a;
for(a=0;a<=x;a++);
}
void motor_clk() // motor moves in clock wise direction
{
      m1=1;m2=0;m3=0;m4=0;
      delay(30000);
 m1=0;m2=1;m3=0;m4=0;
     delay(30000);
      m1=0;m2=0;m3=1;m4=0;
      delay(30000);
      m1=0;m2=0;m3=0;m4=1;
      delay(30000);
 }
```

Direction, steps of stepper motor

```
sbit m1=P0^0;
sbit m2=P0^1;
sbit m3=P0^2;
sbit m4=P0^3;
unsigned int a,b;
void delay(unsigned int x)
{
for(a=0;a<=x;a++);
}
void motor_clk(int y) // motor moves in clock wise direction
{
for(a=0; a<=y; a++)
{
      m1=1;m2=0;m3=0;m4=0;
 delay(30000);
     m1=0;m2=1;m3=0;m4=0;
     delay(30000);
      m1=0;m2=0;m3=1;m4=0;
      delay(30000);
      m1=0;m2=0;m3=0;m4=1;
     delay(30000);
   }
 }
void motor_anticlk(int z)        // motor moves in anticlock wise direction
{
for(a=0; a<=z; a++)
{
m1=0;m2=0;m3=0;m4=1;
     delay(30000);
    m1=0;m2=0;m3=1;m4=0;
    delay(30000);
    m1=0;m2=1;m3=0;m4=0;
    delay(30000);
    m1=1;m2=0;m3=0;m4=0;
    delay(30000);
  }
}
void motor_stop() // motor stops
{
m1=0;m2=0;m3=0;m4=0;
}
void main()
{
while(1)
{
  mov_clk(50);
  motor_stop();
  delay(60000);
  mov_anticlk(50);
  motor_stop();
  delay(60000);
}
```

Direction steps and speed of stepper motor

```
sbit m1=P0^0;
sbit m2=P0^1;
sbit m3=P0^2;
sbit m4=P0^3;
unsigned int a,b;
void delay(unsigned int x)
{
for(a=0;a<=x;a++);
}
void motor_clk(int y, int z) // motor moves in clock wise direction
{
for(a=0; a<=y; a++)
{
      m1=1;m2=0;m3=0;m4=0;
  delay(z);
     m1=0;m2=1;m3=0;m4=0;
     delay(z);
      m1=0;m2=0;m3=1;m4=0;
      delay(z);
      m1=0;m2=0;m3=0;m4=1;
      delay(z);
    }
 }
void motor_anticlk(int u, int v)        // motor moves in anticlock wise direction
{
for(a=0; a<=u; a++)
{
m1=0;m2=0;m3=0;m4=1;
      delay(v);
    m1=0;m2=0;m3=1;m4=0;
    delay(v);
    m1=0;m2=1;m3=0;m4=0;
    delay(v);
    m1=1;m2=0;m3=0;m4=0;
    delay(v);
  }
}
void motor_stop() // motor stops
{
m1=0;m2=0;m3=0;m4=0;
}
void main()
{
while(1)
{
  mov_clk(50,1000);
  motor_stop();
  delay(60000);
  mov_anticlk(50,1000);
  motor_stop();
  delay(60000);
}
```

HC-05 Bluetooth Module

- **Wireless Serial Communication Using HC-05 Bluetooth Module**

HC-05 module is an easy to use **Bluetooth SPP (Serial Port Protocol) module**, designed for transparent wireless serial connection setup.

The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication.

This serial port Bluetooth module is fully qualified **Bluetooth V2.0+EDR (Enhanced Data Rate)** 3Mbps Modulation with complete 2.4GHz radio transceiver and baseband.The Bluetooth module HC-05 is a MASTER/SLAVE module.

By default the factory setting is SLAVE.

The Role of the module (Master or Slave) can be configured only by AT COMMANDS.

The slave modules cannot initiate a connection to another Bluetooth device, but can accept connections.

Master module can initiate a connection to other devices.

The user can use it simply for a serial port replacement to establish connection between MCU and other device wirelessly.

Hardware Features

•3.3 to 5 V I/O.

•PIO(Programmable Input/output) control. •UART interface with programmable baud rate. •With integrated antenna.

Software Features

•Slave default Baud rate: 9600, Data bits:8, Stop bit:1,Parity:No parity.

•Auto-connect to the last device on power as default. •Permit pairing device to connect as default. •Auto-pairing PINCODE:"1234" as default.

Pin Description

- The HC-05 Bluetooth Module has 6pins. They are as follows:
- **ENABLE:** When enable is pulled LOW, the module is disabled which means the module will not turn on and it fails to communicate. When enable is left open or connected to 3.3V, the module is enabled i.e the
    - module remains on and communication also takes place.
- **Vcc:** Supply Voltage 3.3V to 5V
- **GND:** Ground pin
- **TXD & RXD:** These two pins acts as an UART interface for communication
- **Pin Description**

STATE: It acts as a status indicator.

When the module is not connected to / paired with any other Bluetooth device, signal goes Low. At this low state, the led flashes continuously which denotes that the module is not paired with other device.

When this module is connected to/paired with any other Bluetooth device, the signal goes High. At this high state, the led blinks with a constant delay say for example 2s delay which indicates that the module is paired.

BUTTON SWITCH: This is used to switch the module into AT command mode. To enable AT command mode, press the button switch for a second. With the help of AT commands, the user can change the parameters of this

module but only when the module is not paired with any other BT device. If the module is connected to any other Bluetooth device, it starts to communicate with that device and fails to work in AT

command mode.

APPLICATIONS

- Wireless mobile controlled HOME AUTOMATION WIRELESS MOBILE CONTROLLEED ROBOT.
- Wireless nodes to received data to mobiles.
- Send data wirelessly from mobile to microcontroller to turn on and off the LEDs on 8051 microcontroller board.

Slave

```
#include <reg52.h>
void main()
{
unsigned char temp;
TMOD = 0x20; // timer1 mode2 SCON=0x50 ; // mode1 r-en
TH1=0x0FD ; //9600 baud rate TR1=1; //on timer1
if (temp=='1')
P1=0x00; // port 1 off
while(1)

{
P1=(0X01<<4); // LED1 glow
}
else if (temp=='2')
{
P1=(0X01<<5); // LED1 glow
}
else if (temp=='3')
Logic to generate control action
{
P1=(0X01<<6); // LED1 glow

based on received data }
}
```

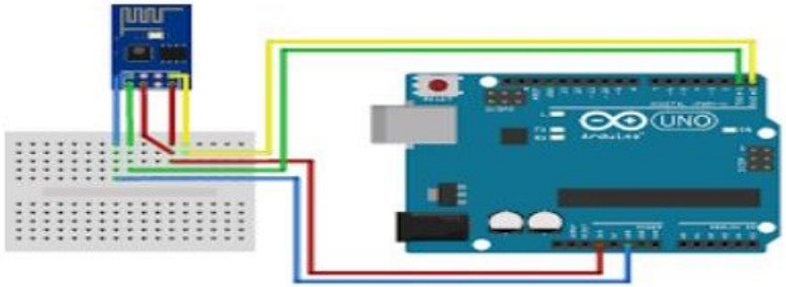
```
//rx while(!RI); // wait till RI
become 1
 Wait till serial data is
received
temp=SBUF; // collect
received data into variable
temp RI=0; // Clear RI flag else
if (temp=='4')
 {
 P1=(0X01<<7); // LED1 glow }
 else if (SBUF=='5')
{
 P1=(0X00); // LED1 off }
 }
 }
```

ESP – 8266 Wifi module

- The ESP8266 can be controlled from your local Wi-Fi network or from the internet (after port forwarding). The ESP-01 module has GPIO pins that can be programmed to turn an LED or a relay ON/OFF through the internet. The module can be programmed using an Arduino/USB-to-TTL converter through the serial pins (RX,TX).

Connection.

ESP8266 ESP-01	Arduino UNO
TX	Pin1
RX	Pin 0
CH_PD	3.3 V
RST	Unwired
VCC	3.3 V
GND	GND
GPIO2	Unwired
GPIO0	Unwired

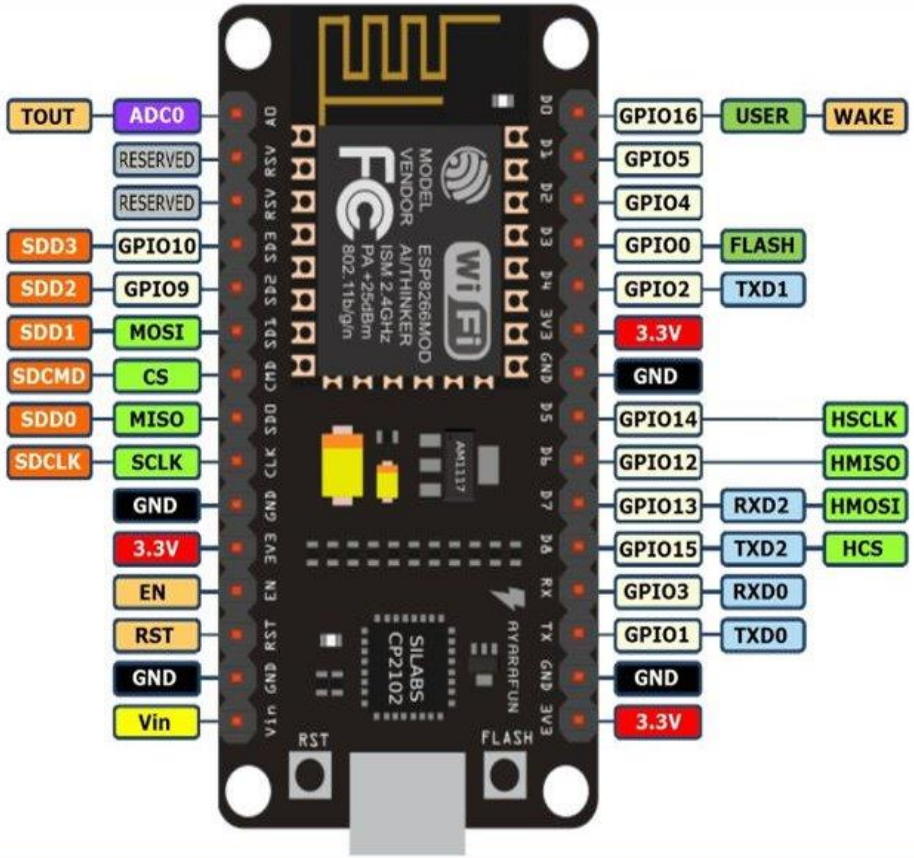


Communication With Nodemcu

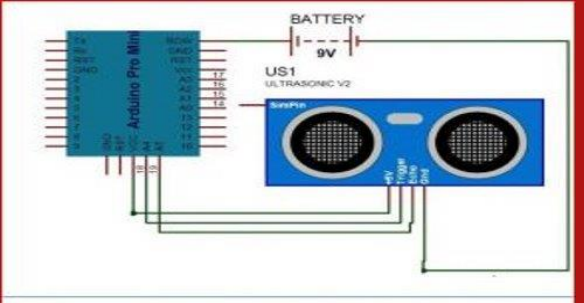
UART

I2C

SPI



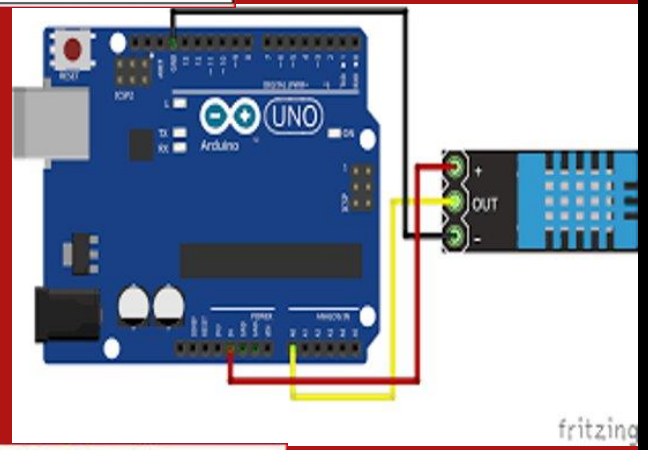
- UART, or Universal Asynchronous Receiver/Transmitter, is a form of serial communication that relies on just one wire going in either direction. UART is done via pins Rx and Tx, which are respectively used to receive and transmit.
- Inter-integrated circuit does have a separate clock signal, but uses just one wire for data transmission. It's great for connecting a single master device to multiple slaves, each of which has a separate address.
- serial peripheral interface, It's commonly used to connect microcontrollers and other integrated circuits. It's also full-duplex, which means that every read operation is able to coincide with a write operation. On the NodeMCU, SPI uses three pins: D5 is the CLK; D6 is the Master In Slave Out (or MISO); D7 is the Master Out Slave In (MOSI).

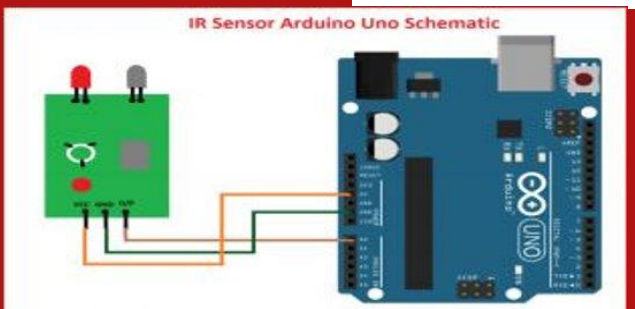


Connection

Arduino	Ultrasonic sensor
7	Echo pin
8	Trig pin
VCC	VCC
GND	GND

Sensors with Arduino





Connection

Arduino	IR sensor
Output	A0
VCC	VCC
GND	GND

- HC-SR04
- **DHT 11**
- **IR Sensor**

Program for HC-SR04

```
#define echopin 7
#define trigPin 7
Long duration, distance:
Void setup()
{
Serial.begin(9600);
PinMode(trigpin,OUTPUT);//Trigger pin

PinMode(echopin,INPUT);//Echo pin
}
Void loop()
{
digitalWrite (trigPin,LOW);
DelayMicroseconds(2);
DigitalWrite(trigPin,LOW);
//Now lets read the bounced wave
duration = pulseIn(echoPin, HIGH);
//calculate the distance
distance = (duration/58.138)*.39;
Serial.print("cm");
Serial.print(distance);
Delay(1000);
}
```

Serial communication

- ***Type of Communication***

1. *Parallel*
2. *Serial*

- **UART in 8051**

An **UART**, *universal asynchronous receiver / transmitter* is responsible for performing the main task in serial communications with computers.

The device changes incoming parallel information to serial data which can be sent on a communication line. A second **UART** can be used to receive the information.
To communicate with pc or other devices we need some standards like RS232.

A driver(MAX232) is used to convert TTL level to RS232 voltage level.

PROJECTS

- FIRST_ROBOT
- Device used -

Microchip , AT89C51

Program to be used

PROJECTS

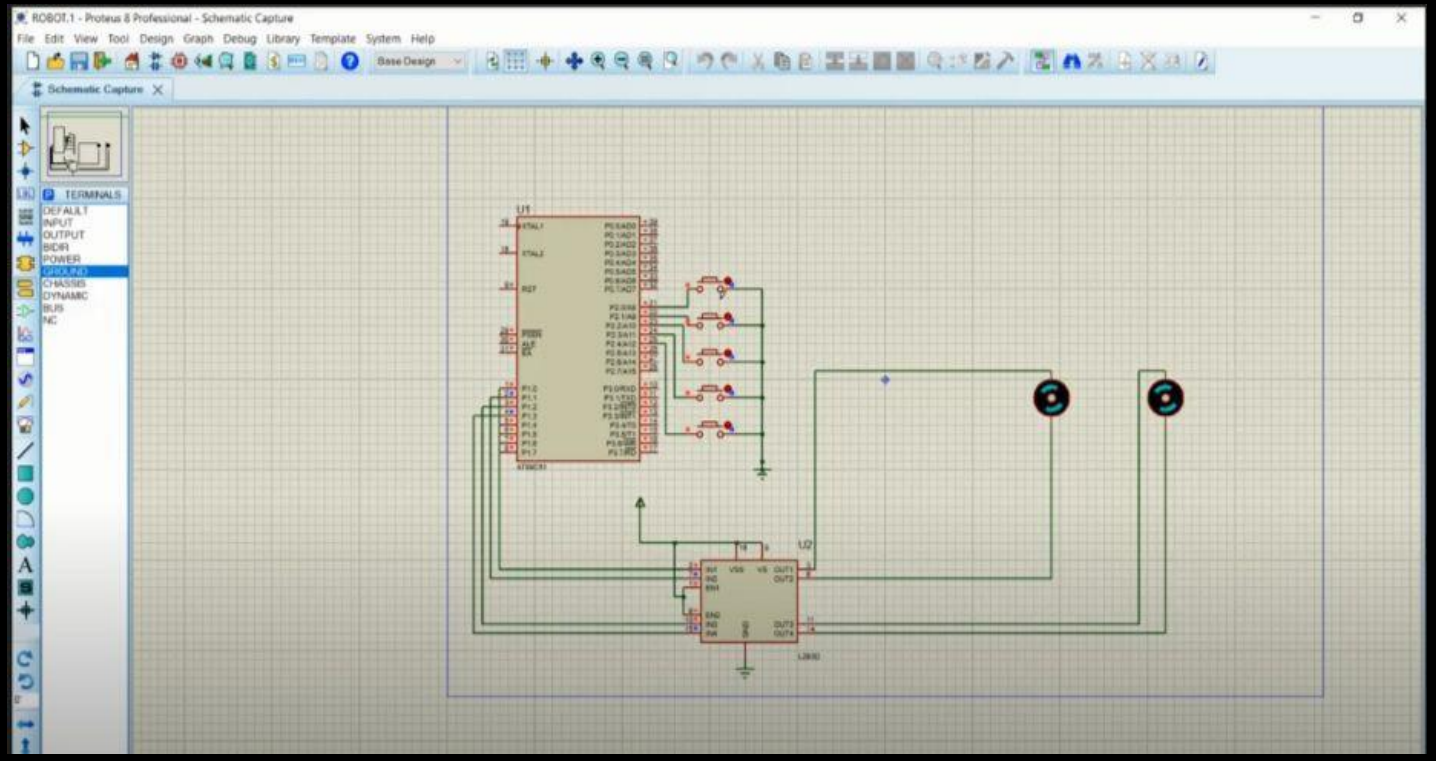
```
//PROGRAM_TO_FOLLOW
#include<reg51.h>
sbit mot1p=P1^0;
sbit mot1n=P1^1;
sbit mot2p=P1^2;
sbit mot2n=P1^3;
//connectivity_of_the_motors//
sbit sw1=P2^0;//forward_direction
sbit sw2=P2^1;//reverse_direction
sbit sw3=P2^2;//left_direction
sbit sw4=P2^3;//right_direction
sbit sw5=P2^4;//stop
void main()
{
    mot1p=mot1n=mot2p=mot2n=0;
    while(1)
    {
      if(sw1==0)
      {
        mot1p=1;
        mot1n=0;
        mot2p=1;
        mot2n=0;//robot_moves_forward_direction
      }
```

PROJECTS

```
        if(sw2==0)
        {
          mot1p=0;
          mot1n=1;
          mot2p=0;
          mot2n=1;//robot_moves_reverse_direction
        }
    if(sw3==0)
        {
          mot1p=0;
          mot1n=1;
          mot2p=1;
          mot2n=0;//robot_moves_left_direction
        }
        if(sw4==0)
        {
          mot1p=1;
          mot1n=0;
          mot2p=0;
          mot2n=1;//robot_moves_right_direction
        }
        if(sw5==0)
        {
          mot1p=mot1n=mot2p=mot2n=0;
        }
      }
  }
```

PROJECTS

OUTPUT



PROJECTS

- LCD
- Device used -

LM016L, AT89C51

PROJECTS

//PROGRAM_TO_FOLLOW

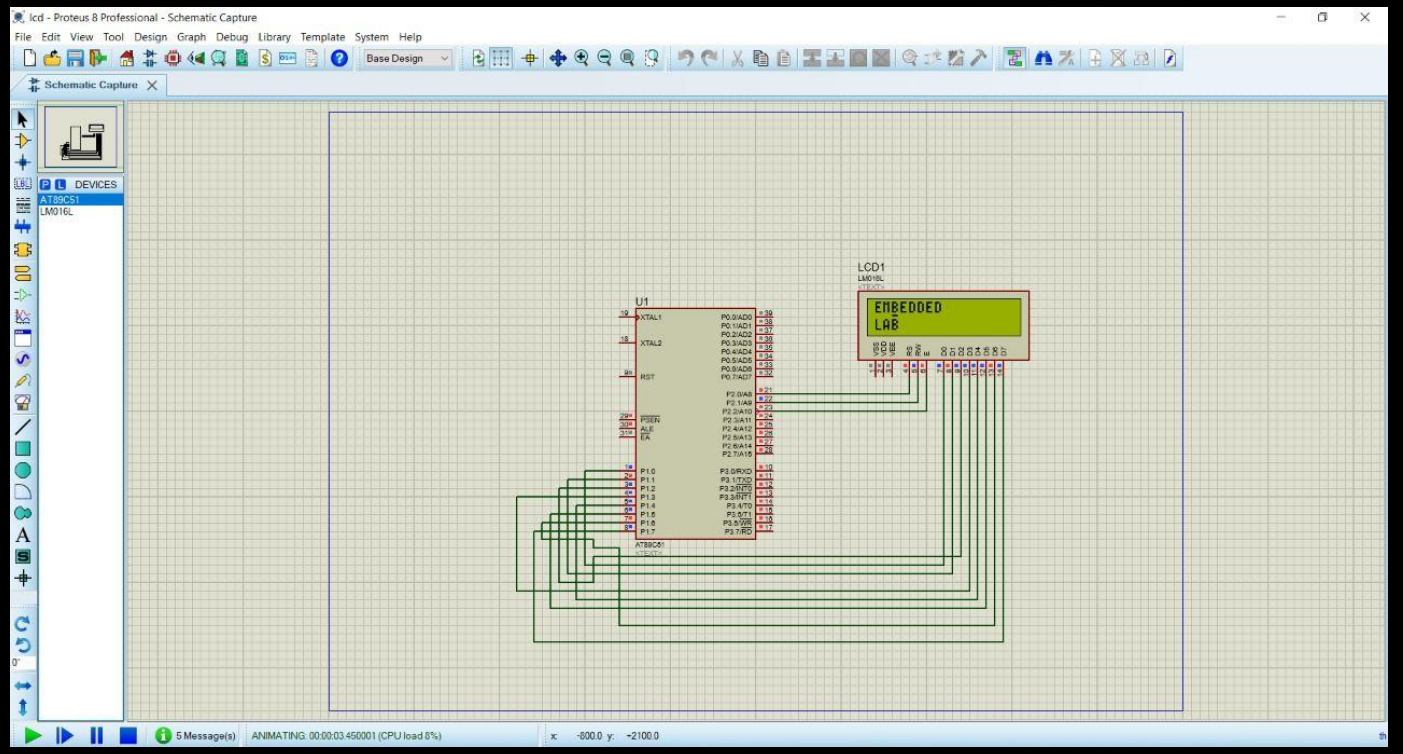
```
#include<reg52.h>

//     RS      RW      E        D0 -  D7
//    P2.0    P2.1    P2.2    P1.0 - P1.7
//#define
sbit RS=P2^0;
sbit RW=P2^1;
sbit E=P2^2;

void send_command(unsigned int command_value ) ;
void send_data(unsigned int data_value) ;
void ms_delay( unsigned int time);

void main()
{

//LCD INITIALIZATION

//2 lines and 5x7 matrix
send_command(0x38);

//display on cursor blink
send_command(0x0E);

//clear display screen
send_command(0X01);



//PRINTING A CHARACTER

while(1)
{

send_command(0x80)      ; // force cursor on 1st line
send_data('E');
send_data('M');
send_data('B');
send_data('E');
send_data('D');
send_data('D');
```

PROJECTS

```
send_data('E');
send_data('D');

send_command(0xC0)      ; // force cursor on 2nd line

send_data('L');
send_data('A');
send_data('B');

}

}


void send_command(unsigned int command_value )
{
        P1=command_value;
        RW=0;
        RS=0;
        E=1;
        ms_delay(10);
        E=0;
}

void send_data(unsigned int data_value)
{
        P1=data_value;
        RW=0;
        RS=1;
        E=1;
        ms_delay(10);
        E=0;
}

void ms_delay( unsigned int time)
{
        unsigned int i,j;
        //time X 1ms
        for(i=0;i<time;i++)
        {
                for(j=0;j<113;j++);  //1 ms
        }
}
```

PROJECTS

OUTPUT



PROJECTS

- Timer
- Device used - AT89C51

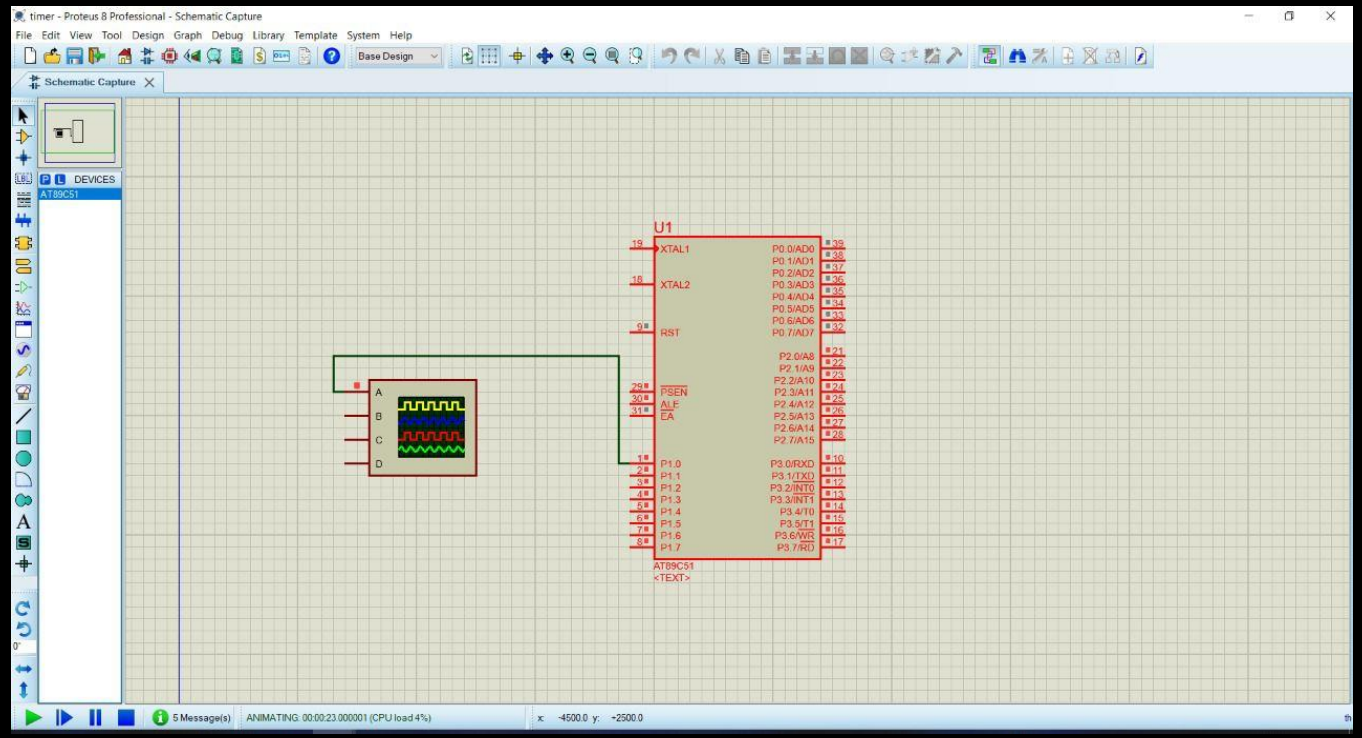
PROJECTS

- //PROGRAM_TO_FOLLOW

```
#include<reg52.h>

void ms_delay();

void main()
{

TMOD=0X01; //timer 0, mode 1, 16 bit mode
while(1)
{
P1=0XFF;
ms_delay();
P1=0X00;
ms_delay();
}
}


void ms_delay()    // 5ms
{
TL0=0x00;
TH0=0x0EE; // 5ms

TR0=1;

while(!TF0);

TR0=0; //timer off
TF0=0;
}
```

PROJECTS

OUTPUT



PROJECTS

- PWM
- Device used - AT89C51

PROJECTS

- //PROGRAM_TO_FOLLOW

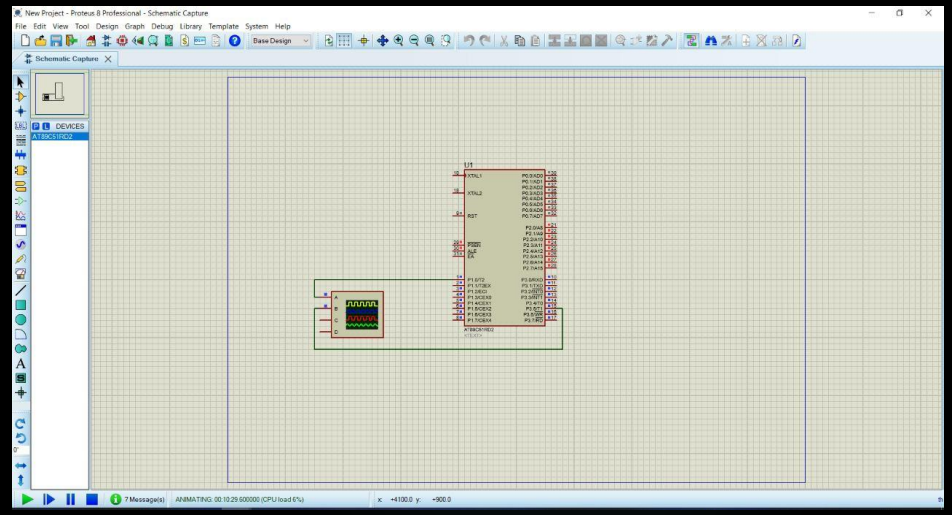
```
// blink led P1

#include<reg52.h>

void ms_delay( unsigned int time);

void main()
{
        int x;

        while(1)
        {
        for(x=0;x<=200;x++)
        {
        P1=0x0ff;  //on led
                P3=(0x01<<5);  //on motor
        ms_delay(1);// delay 1s
        P1=0x00; // off led
        P3=0x00;  //off motor
        ms_delay(9);
        }

                for(x=0;x<=200;x++)
        {
        P1=0x0ff;  //on led
                P3=(0x01<<5);  //on motor
        ms_delay(5);// delay 1s
        P1=0x00; // off led
                P3=0x00;  //off motor
        ms_delay(5);
        }

                for(x=0;x<=200;x++)
        {
        P1=0x0ff;  //on led
                P3=(0x01<<5);  //on motor
        ms_delay(9);// delay 1s
        P1=0x00; // off led
                P3=0x00;  //off motor
        ms_delay(1);
        }
```

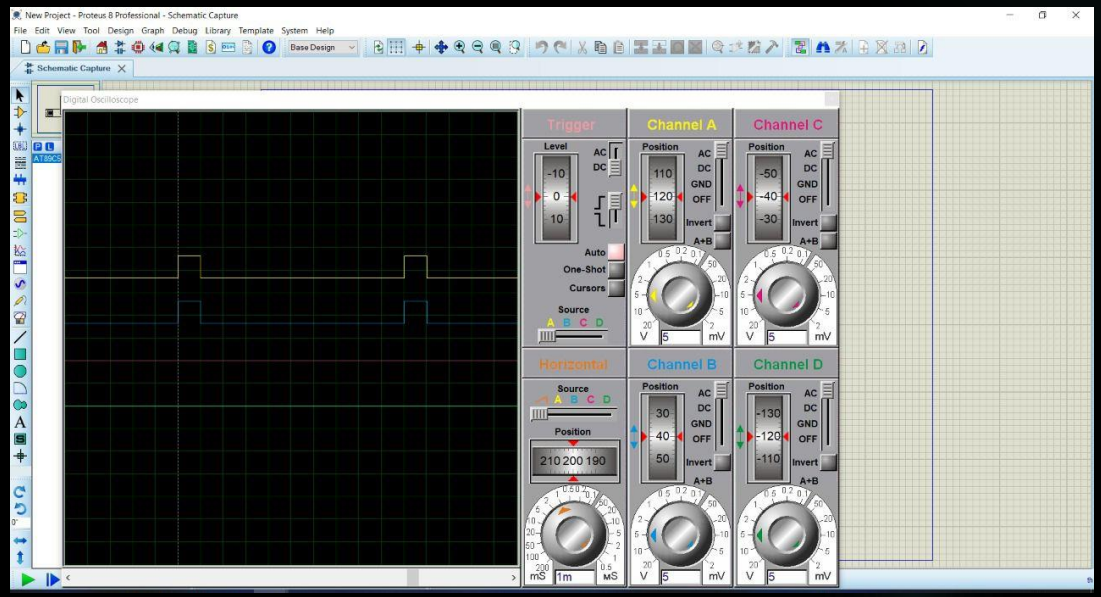
PROJECTS

```
}
        )

void ms_delay( unsigned int time)
{
        unsigned int i,j;
        //time X 1ms
        for(i=0;i<time;i++)
        {
                for(j=0;j<113;j++);   //1 ms
        )
}
```

PROJECTS

OUTPUT





CERTIFICATE

सत्यमेव जयते
MINISTRY OF MICRO, SMALL & MEDIUM ENTERPRISES
GOVERNMENT OF INDIA

MSME-TECHNOLOGY DEVELOPMENT CENTRE (PPDC)
एम0एस0एम0ई0 - तकनीकी विकास केन्द्र
Ministry of Micro, Small & Medium Enterprises
सूक्ष्म, लघु एवं मध्यम उद्यम मंत्रालय
Government of India Organization
भारत सरकार की संस्था
Foundry Nagar, Agra-282 006 (U.P.)
फाउन्ड्री नगर, आगरा–282 006 (उ0प्र0)

प्रमाण पत्र

Certificate

This is to certify that

MR. PUSHPAL DAS

has successfully completed online training

on

MICRO CONTROLLER PROGRAMMING

from 04.08.2021 to 03.09.2021

DATE : September 27, 2021
PLACE : AGRA

R.PANNEERSELVAM
PRINCIPAL DIRECTOR

No. PPDC/Trg./OSP/2021-22/13816