

Microcontroller

Microcontrollers may be called computers on-chip. A combination of a controller, internal ROM, RAM, parallel and serial ports is a Microcontroller. Microcontrollers are dedicated devices embedded within an application. Ex:- as an engine controller in automobiles, as an exposure and focus controller in cameras. On-chip peripheral is selected depending on the specifics of the target application.

As we know that the Microcontrollers are powerful digital processors, the degree of control and programmability in which they provide significantly enhances the effectiveness of the application.

Types of Microcontroller

(1) 8051 (2) PIC (3) AVR (4) ARM

8051 Microcontroller

Intel designed the first microcontroller and this is known as the 8051 microcontrollers. This microcontroller was introduced in the late 1970 and in 1981 it was developed by Intel.

8051 microcontroller is an 8-bit microcontroller. 8051 microcontroller has the ability to read, write and process 8-bit data. It is widely used in embedded systems, consumer electronics, robotics, etc. The peripherals of this microcontroller are integrated into a single chip, and the overall system cost is very low.

The size of the product is small as compared to the microcontroller-based system thus very handy. All features are available in 40 pin IC of the 8051 microcontrollers.

Applications of 8051 microcontrollers:

- (1) Home appliances like Microwave Oven, Washing machines, etc.
- (2) Light sensing and controlling devices like audio systems.
- (3) Temperature sensing and control devices.
- (4) Fire detection and safety devices such as home security systems.
- (5) Other devices like calculator, ATM machine, etc.

PIC Microcontroller

PIC stands for Programmable Interface Controllers. It was developed by a Microchip average. It is fast and simple to implement program when we compare with other microcontrollers like 8051. The ease of programming and simple to interfacing with other peripherals PIC become successful microcontroller.



These are electronic circuits that can be programmed to carry out a vast range of tasks. It consists of memory structure, input/output ports, timers, A/D Converter, Oscillators, CCP module. PIC Microcontrollers are relatively cheap. PIC devices are familiar with both industrial developers and hobbyists due to their low cost, wide availability, large user base, extensive collection of application notes, serial programming, free development tools, and reprogrammable flash memory capability.

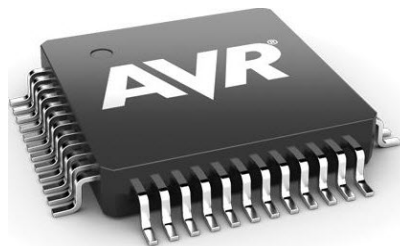
- (1) **Features of PIC Microcontroller**
- (2) Flash memory
- (3) Watchdog Timer
- (4) Sleep mode
- (5) EEPROM memory

Applications of PIC Microcontroller: -

- (1) Mobile Phones
- (2) Computer control systems
- (3) Alarm systems
- (4) Embedded systems

AVR Microcontroller

AVR microcontroller was developed in the year of 1996 by Atmel Corporation. The structural design of AVR was developed by the Alf-Egil Bogen and Vegard Wollan. It is commonly accepted that AVR stands for Alf and Vegard's RISC microcontroller, which is also known as Advanced Virtual RISC. The AT90S8515 was the initial microcontroller which was based on the AVR architecture, though the first microcontroller to hit the commercial market was AT90S1200 in the year 1997.



This microcontroller is the advanced version of a microcontroller. It contains a chip CPU, ROM, RAM, input/output unit, interrupts controller, etc. This microcontroller is used for high-speed signal processing operation which is connected inside an embedded system.

AVR Microcontrollers are Available in three categories: -

- 1) **TinyAVR:-** Less memory, small size, appropriate just for simpler applications
- 2) **MegaAVR:-** These are the mainly popular ones having a good quantity of memory (up to 256 KB), higher number of inbuilt peripherals and appropriate for modest to complex applications.
- 3) **XmegaAVR:-** Used in commercial for complex applications, which need large program memory and high speed.

Features of AVR Microcontroller

- 1) 32×8 general working function registers.
- 2) 32k bytes of in-system self-programmable flash program memory.
- 3) 2k bytes of internal SRAM.
- 4) 1024bytes of EEPROM.
- 5) Available in 40 pin DIP, 44lead QTFP, 44-pad QFN/MLF.
- 6) 32 programmable I/O lines.
- 7) 8 channel, 10bit ADC.
- 8) Harvard architecture.
- 9) UART, I2C, SPI protocol support

Applications of AVR Microcontroller: -

- (1) AVR microcontroller is mainly used in an embedded system for the operation of high-speed signal processing.
- (2) These microcontrollers are used in touch screens, home automation, medical devices, defence, automobiles, etc.
- (3) This microcontroller can be used in many types of projects like data acquisition, motion control, For signal sensing, interface GPS, GSM, motors, displays on LCD, unmanned aerial vehicles development, etc.

ARM Processor

Advanced RISC Machine (ARM) this microcontroller was introduced by Acron Computer Organization. It is manufactured by Apple, Qualcomm, Motorola, etc. The Processor of the ARM microcontroller belongs to the family of CPUs which are based on Reduced Instruction Set Computer (RISC) and also ARM Microprocessor. An ARM makes at 32-bit and 64-bit RISC multi-core processors. The speed of the ARM microcontroller is 1 clock cycle per machine cycle and the power consumption is low. The popular microcontroller of ARM includes ARM Cortex-M0 to ARM Cortex-M7, etc.



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Features of ARM Microcontroller:-

- 1) It must have the ability to control different types of software.
- 2) It is compatible with the sleep mode of operation.
- 3) Flash, EEPROM, SDRAM memory is used in ARM microcontroller.
- 4) ARM consists of an Arithmetic logic unit, booth multiplier, barrel shifter, control unit, register file.
- 5) It consists of a three-stage pipeline.

Three-stage pipeline

S1 Fetch: - The instruction is fetched from memory and placed in the instruction pipeline.

S2. Decode:- The instruction is decoded and the datapath control signals are prepared for the next cycle. In this stage, the instruction owns the decode logic but not the datapath.

S3. Execute:- The instruction owns the datapath; the register bank is read, an operand shifted, the ALU register generated and written back into a destination register.

Applications Of ARM Microcontroller: -

- 1) ARM microcontroller is used in space and aerospace.
- 2) Used in medical devices such as MRI Machines, ultrasound machines.
- 3) Used in accelerators, nuclear reactors, and X-ray machines.
- 4) ARM processors are widely used in customer electronic devices such as smart phones, tablets, multimedia players and other mobile devices

Main Difference between features of AVR, ARM, 8051 and PIC Microcontrollers: -

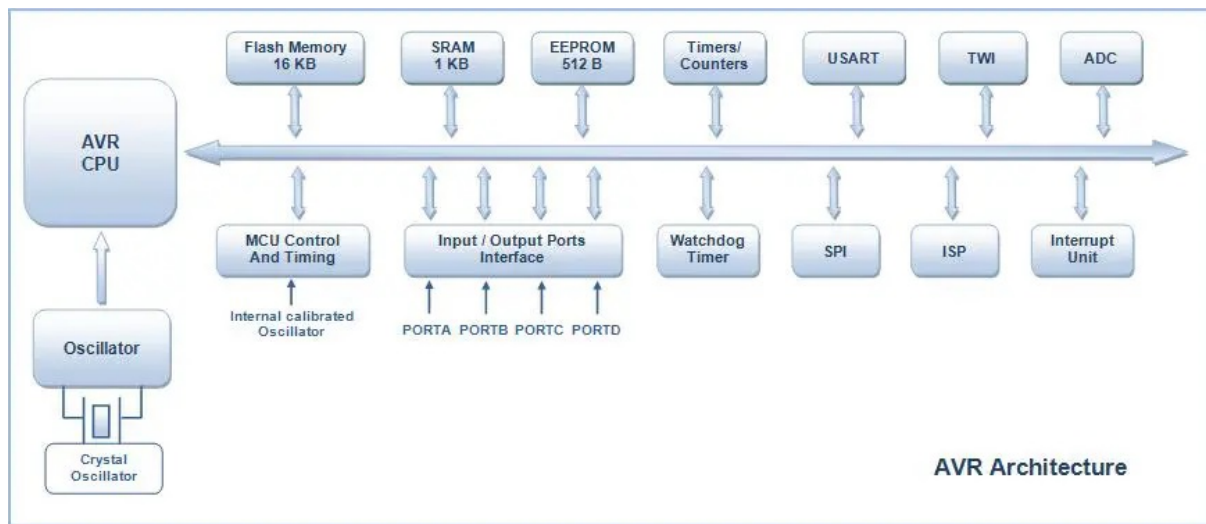
S.No.	Features	AVR	ARM	8051	PIC
1	Manufacturer	Atmel	Apple, Nvidia, Qualcomm, Samsung	NXP, Atmel, Silicon Labs, Dallas, Cypress, Infineon, etc.	Microchip Average
2	Bus Width	8/32-bit	32-bit mostly also available in 64-bit	8-bit for standard core	8/16/32-bit
3	Speed	1 clock/ instruction cycle	1 clock/ instruction cycle	12 Clock/instruction cycle	4 Clock/instruction cycle
4	Memory Architecture	Modified Harvard architecture	Modified Harvard architecture	Harvard architecture	Von Neumann architecture
5	Memory	Flash, SRAM, EEPROM	Flash, SDRAM, EEPROM	ROM, SRAM, FLASH	SRAM, FLASH
6	Instruction Set Architecture (ISA)	RISC	RISC	CISC	Some feature of RISC
7	Community	Very Good	Vast	Vast	Very Good
8	Power Consumption	Low	Low	Average	Low
9	Families	Tiny, Atmega, Xmega, special purpose AVR	ARMv4,5,6, 7 and series	8051 variants	PIC16, PIC17, PIC18, PIC24, PIC32
10	Popular Microcontrollers	Atmega8, 16, 32, Arduino Community	LPC2148, ARM Cortex-M0 to ARM Cortex-M7, etc	AT89C51, P89v51, etc.	PIC18fXX8, PIC16f88X, PIC32MXX

AVR Microcontroller Architecture

The architecture of AVR microcontrollers is based on the advanced RISC & it includes 32 x 8-bit general-purpose registers. In a single CLK cycle, this microcontroller can get inputs from two registers to connect them to ALU for the requested operation & move back the result to an arbitrary register. Here, the ALU performs arithmetic & logical operations on the inputs from the register.

AVR can execute single cycle execution which means this microcontroller can perform 1 million instructions for each second if the frequency of the cycle is 1MHz. If the operating frequency of the controller is higher, then its processing speed will be higher. So the power consumption needs to optimize with processing speed & thus need to choose the operating frequency accordingly.

The architecture of the AVR microcontroller includes different building blocks and each block is explained in the AVR microcontroller block diagram shown below.



I/O Ports

AVR microcontroller includes four 8-bit input-output ports like PORT-A, PORT-B, PORT-C & PORT-D.

Internal Calibrated Oscillator

AVR microcontroller includes an internal oscillator used for driving its CLK. This microcontroller is set to work at a 1 MHz internal calibrated oscillator. So the maximum internal oscillator frequency is 8 MHz

ADC Interface

This microcontroller includes an 8-channel ADC with a 10-bits resolution. The main function of this ADC is to read the analog input.

Timers/Counters

The microcontroller includes two 8-bit & one 16-bit timer/counter. The main function of timers in this controller is to generate precision actions like time delays created in between two operations.

Watchdog Timer

In this microcontroller, the watchdog timer is present with an internal oscillator. The main function of this is to monitor and reset the controller continuously if the code gets trapped while executing in a defined time interval.

Interrupts

This microcontroller includes 21 interrupts where 16 interrupts are internal and the remaining interrupts are external. Here internal interrupts support different peripherals like ADC, USART, Timers, etc.

USART

The term USART stands for "Universal Synchronous and Asynchronous Receiver" & interface of the transmitter is obtainable to interface with an external device that is capable of communicating serially.

General Purpose Registers

This microcontroller has 32 general-purpose registers where these registers are connected with the ALU of the CPU directly.

Memory

The memory of this microcontroller includes three different sections

Flash EEPROM

This type of memory is helpful in storing the program dumped by the user into the AVR microcontroller. This program can be simply removed electrically like a single unit. This memory is non-volatile which means if the power is gone then the program will not erase. This microcontroller includes 16KB of in-system programmable Flash EEPROM.

Byte Addressable EEPROM

Byte addressable EEPROM is a non-volatile memory that is mainly used for data storage. This microcontroller includes EEPROM- 512 bytes, so this memory can be simply helpful in storing the lock code if we are designing an electronic door lock application.

SRAM

SRAM stands for Static Random Access Memory which is the volatile memory of the AVR microcontroller so the data will be lost once power is deactivated. This microcontroller includes 1KB – of internal SRAM. A small part of SRAM is reserved for general purpose registers which are used by the CPU & also some other peripheral subsystems.

ISP

These microcontrollers include In-System Programmable Flash Memory or ISP that can be simply programmed without detaching the chip from the circuit; this allows for reprogramming of the microcontroller when it is within the application circuit.

SPI

The term SPI stands for Serial Peripheral Interface, which is mainly used for serial communication between two different devices on a common CLK source. The SPI data transmission speed is high as compared to USART.

TWI

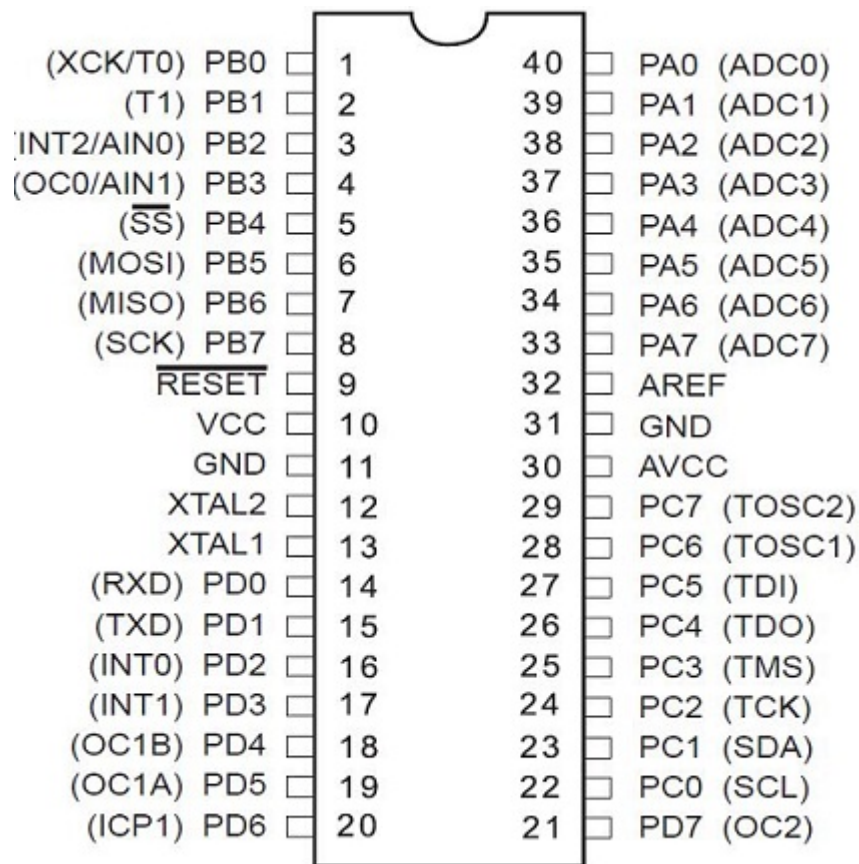
TWI is a Two-Wire Interface that can be used to connect a network for devices, so several devices can be simply connected above this interface to form this network so that the transmission of data can be done simultaneously by devices with their own unique address.

DAC

The DAC or Digital to Analog Converter in the microcontroller is used to perform the reverse action of ADC. This converter is simply used whenever there is a requirement of changing a signal from digital to analog.

AVR Microcontroller PinOut/PinDiagram

The AVR Atmega 32 microcontroller **pin configuration** is shown below. This microcontroller includes four ports port-A, port-B, port-C, and port-D. Port-A mainly includes pins from PA7to PA0, port-B includes PB7 to PB0, port-C includes from PC7 to PC0 and port-D includes from PD7 to PD0.



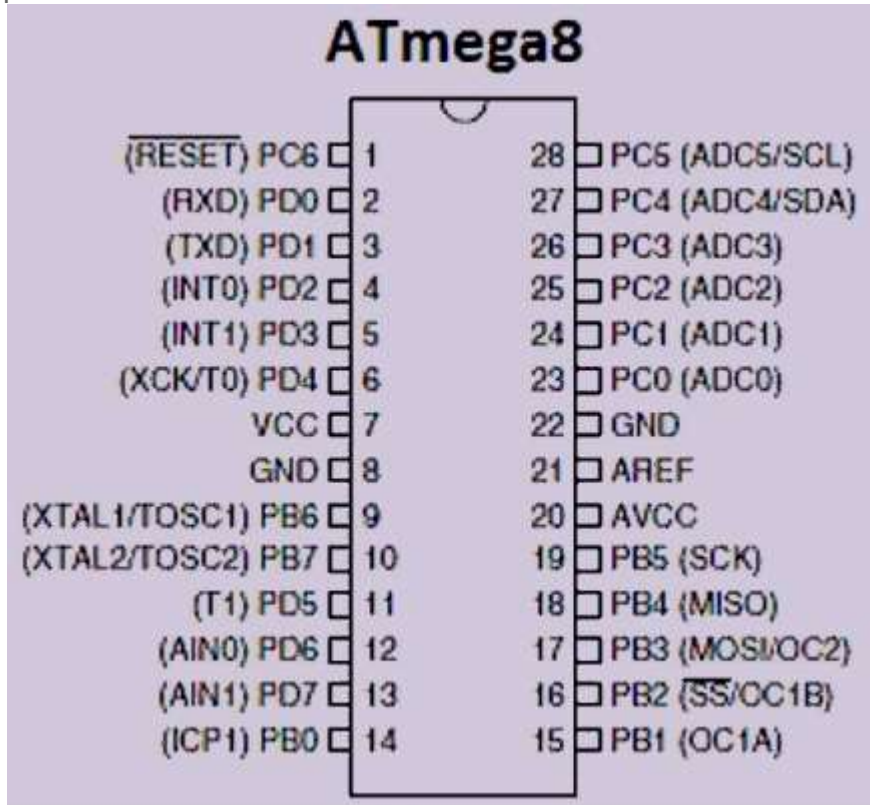
What is an AVR Atmega8 Microcontroller?

In 1996, AVR Microcontroller was produced by the “Atmel Corporation”. The Microcontroller includes the Harvard architecture that works rapidly with the RISC. The features of this Microcontroller include different features compared with other like sleep modes-6, inbuilt ADC (analog to digital converter), internal oscillator and serial data communication, performs the instructions in a single execution cycle. These Microcontrollers were very fast and they utilize low power to work in different power saving modes. There are different configurations of AVR microcontrollers are available to perform various operations like 8-bit, 16-bit, and 32-bit. AVR microcontrollers are available in three different categories such as TinyAVR, MegaAVR, and XmegaAVR

1. The Tiny AVR microcontroller is very small in size and used in many simple applications
2. Mega AVR microcontroller is very famous due to a large number of integrated components, good memory, and used in modern to multiple applications
3. The Xmega AVR microcontroller is applied in difficult applications, which require high speed and huge program memory.
- 4.

Atmega8 Microcontroller Pin Description

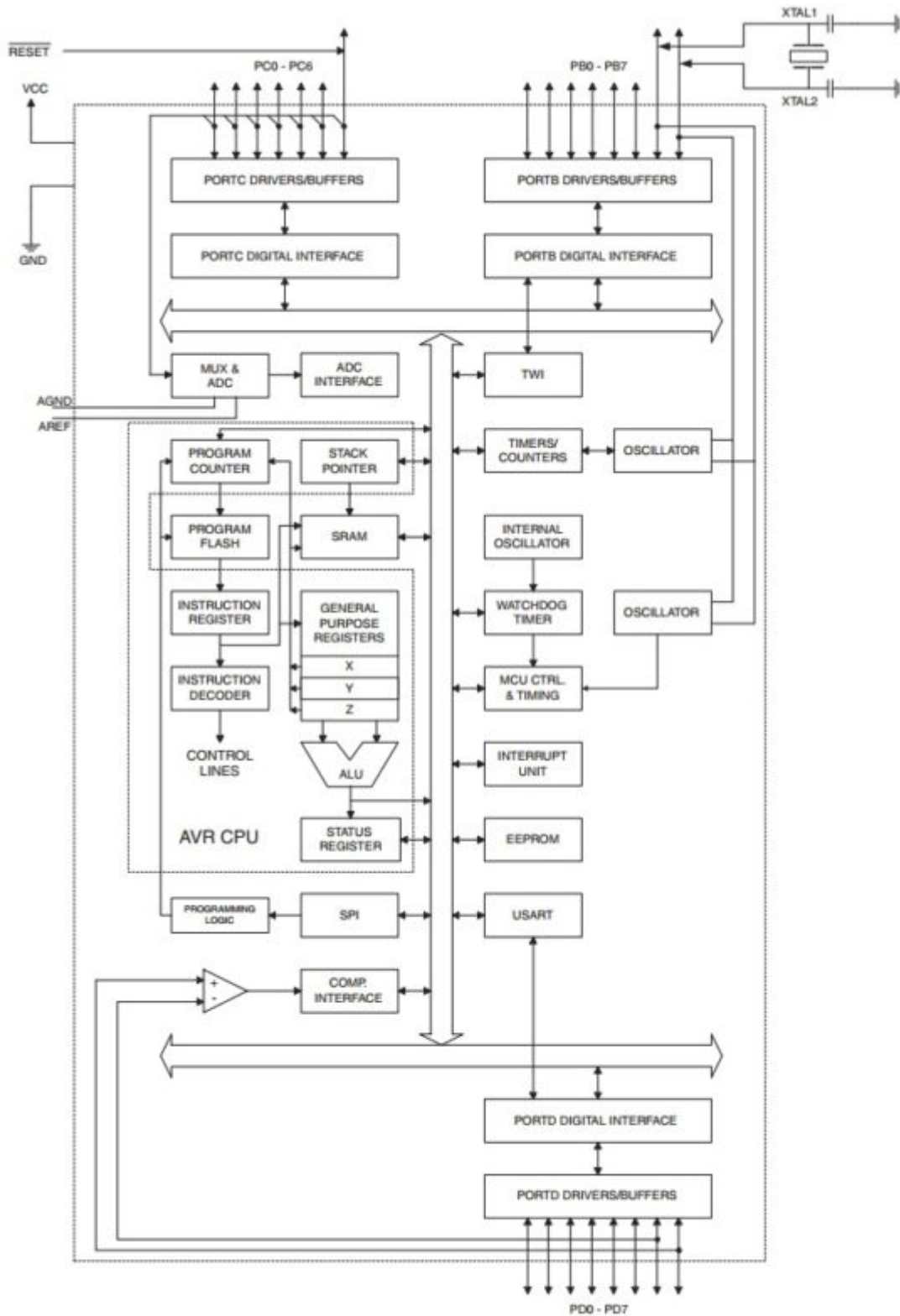
The main feature of Atmega8 Microcontroller is that all the pins of the Microcontroller support two signals except 5-pins. The Atmega8 microcontroller consists of 28 pins where pins 9,10,14,15,16,17,18,19 are used for port B, Pins 23,24,25,26,27,28 and 1 are used for port C and pins 2,3,4,5,6,11,12 are used for port D.



- Pin -1 is the RST (Reset) pin and applying a low-level signal for a time longer than the minimum pulse length will produce a RESET.
- Pin-2 and pin-3 are used in USART for serial communication.
- Pin-4 and pin-5 are used as an external interrupt. One of them will activate when an interrupt flag bit of the status register is set and the other will activate as long as the intrude condition succeeds.
- Pin-9 & pin-10 are used as a timer counters oscillators as well as an external oscillator where the crystal is associated directly with the two pins. Pin-10 is used for low-frequency crystal oscillator or crystal oscillator. If the internal adjusted RC oscillator is used as the CLK source & the asynchronous timer is allowed, these pins can be utilized as a timer oscillator pin.
- Pin-19 is used as a Master CLK o/p, slave CLK i/p for the SPI-channel.
- Pin-18 is used as Master CLK i/p, slave CLK o/p.
- Pin-17 is used as Master data o/p, slave data i/p for the SPI-channel. It is used as an i/p when empowered by a slave & is bidirectional when allowed by the master. This pin can also be utilized as an o/p compare with match o/p, which helps as an external o/p for the timer/counter.
- Pin-16 is used as a slave choice i/p. It can also be used as a timer or counter1 comparatively by arranging the PB2-pin as an o/p.
- Pin-15 can be used as an external o/p of the timer or counter compare match A.
- Pin-23 to Pins28 have used for ADC (digital value of analog input) channels. Pin-27 can also be used as a serial interface CLK & pin-28 can be used as a serial interface data
- Pin-12 and pin-13 are used as an Analog Comparator i/ps.
- Pin-6 and pin-11 are used as timer/counter sources.

Atmega8 AVR Microcontroller Architecture

The Atmega AVR Microcontroller architecture includes the following blocks.



Memory: It has 1Kbyte Internal SRAM, 8 Kb of Flash program memory and 512 Bytes of EEPROM.

I/O Ports: It has three ports, namely port-B, port-C, and port-D and 23 I/O line can be attained from these ports.

Interrupts: The two Exterior Interrupt sources are located at port D. Nineteen dissimilar interrupts vectors supporting nineteen events produced by interior peripherals.

Timer/Counter: There are 3-Internal Timers are accessible, 8 bit-2, 16 bit-1, presenting numerous operating modes & supporting internal/external clocking.

Serial Peripheral Interface (SPI): ATmega8 microcontroller holds three integrated communication devices. One of them is an SPI, 4-pins are allocated to the Microcontroller to implement this system of communication.

USART: USART is one of the most powerful communication solutions. Microcontroller ATmega8 supports both synchronous & asynchronous data transmission schemes. It has three pins allocated for that. In many communication projects, the USART module is widely used for communication with PC-Microcontroller.

Two-Wire Interface (TWI): TWI is another communication device that is present in the ATmega8 microcontroller. It permits designers to set up a communication b/n two devices using two wires along with a mutual GND connection, As the o/p of the TWI is made using open collector o/ps, therefore external pull-up resistors are compulsory to make the circuit.

Analog Comparator: This module is incorporated in the integrated circuit that offers a contrast facility between two voltages linked to the two inputs of the comparator through External pins associated with the Microcontroller.

ADC: Inbuilt ADC (analog to digital converter) can alter an analog i/p signal into digital data of the 10-bit resolution. For a maximum of the low-end application, this much resolution is sufficient.

Atmega8 Microcontroller Applications

The Atmega8 microcontroller is used to build various electrical and electronic projects. Some of the AVR atmega8 Microcontroller projects are listed below.

1. AVR Microcontroller based LED Matrix Interfacing
2. UART communication between Arduino Uno and ATmega8
3. Interfacing of Optocoupler with ATmega8 Microcontroller
4. AVR Microcontroller based Fire Alarm System
5. Measurement of Light Intensity using AVR Microcontroller and LDR
6. AVR Microcontroller based 100mA Ammeter
7. ATmega8 Microcontroller based Anti-Theft Alarm System
8. AVR Microcontroller based Interfacing of Joystick
9. AVR Microcontroller based Interfacing of Flex Sensor
10. Stepper Motor Control using AVR Microcontroller