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UNIT-5

DESIGN EXAMPLES AND CASE STUDIES

Topics:

Embedded Systems in Automobile, Case study of an Embedded System for an Adaptive Cruise Control(ACC) System in a Car, Case study of an Embedded System for a Smart Card. Case study of Communication between Orchestra Robots, Introduction to AVR family of microcontrollers.(ATmega8).

Embedded systems in Automobile

- Nowadays, embedded systems role in automobiles has been increased. The automobile industries mainly manufacture cars, bikes, buses, etc. In India, if we look back into the past two decades, only rich people have their own cars, but now there are a lot of automobile users are increasing rapidly in the country.
- The embedded systems used in automobiles mainly include security, safety, entertainment systems, and ignition. So this can make the car safer, energy-efficient. At present, the microcontrollers used in automobiles mainly depend on the vehicle. For example, a normal vehicle includes around 25 -35 whereas some luxury vehicles include 60 – 70 microcontrollers.

Some examples are

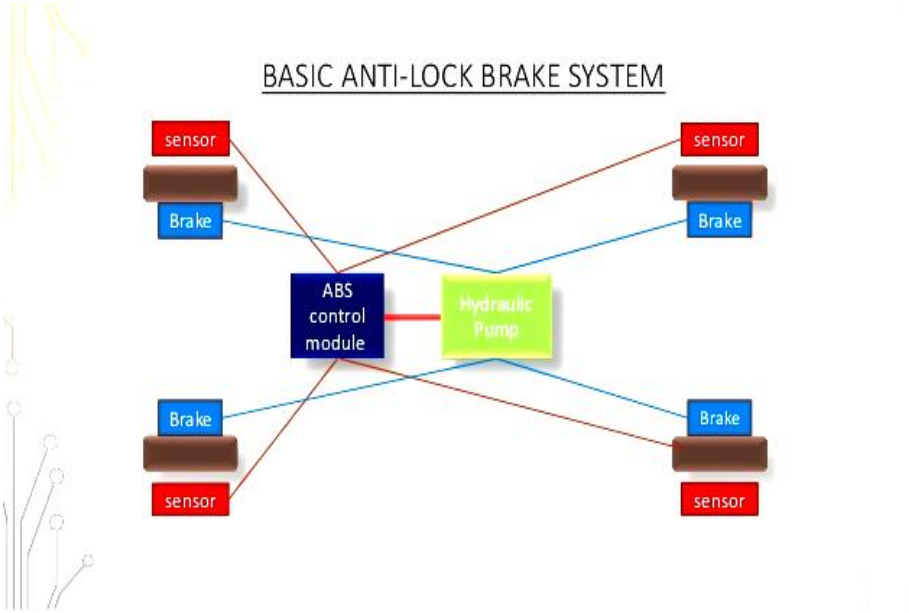
- Airbags
- Anti-lock braking system
- Adaptive cruise control
- In-vehicle entertainment systems
- Night vision, Navigational systems,Tire pressure monitor etc.

Airbag Control System

- Air Bag is a protection device that provides safety against a head-on crash. It is for the individuals sitting in the front. This system works on commands from the airbag control unit, which has a microcontroller. The controller gets power from the battery.
- If the collision sensor detects an accident, a signal is sent to the airbag control unit and it is processed by the airbag control unit to determine severity of the impact. If airbag deployment is necessary, the airbag control unit sends a signal to initiate airbag inflators. Inflators emits nitrogen gas, resulting in the deployment of the airbag cushion.

Antilock Braking systems:

- This is also a very good example of Embedded Systems in automobile industry. Anti-lock brake system is an embedded system used in a car whose main function is to prevent the car getting out of control when the road is slippery.



- This system comes into action when the driver suddenly applies the brakes during an emergency. Employing the antilock braking system on cars is now mandatory in most parts of the world.
- Whenever the driver suddenly applies the brakes to a high-speed vehicle, there is always a chance of the 'wheel-lock.' The wheel-lock means that the respective wheel stops suddenly instead of slowly coming to a halt. Due to the wheel-lock, the driver loses control over the vehicle, and the vehicle skids off the road. Thus, a fatal accident takes place. In order to avoid such situations, the manufacturers employ the ABS

HOW ANTILOCK BRAKING SYSTEM WORKS:

- After receiving the signal of very low speed from the wheel speed sensor, the ABS module orders the brake control unit to reduce that wheel's braking force. Reducing the braking force means reducing the hydraulic pressure in the brake line acting on that wheel.

- The Brake Control Unit reduces the line pressure with the help of valves in the system. When the braking force reduces, the wheel starts rotating faster, thereby avoiding the wheel-lock. As the wheel doesn't lock, the steerability of the vehicle remains intact. This means that the vehicle moves according to the driver's input without skidding. Once the normal condition is restored, the Brake Control Unit restores the brake line's hydraulic pressure with the help of a pump.

Advantages of Antilock braking system:

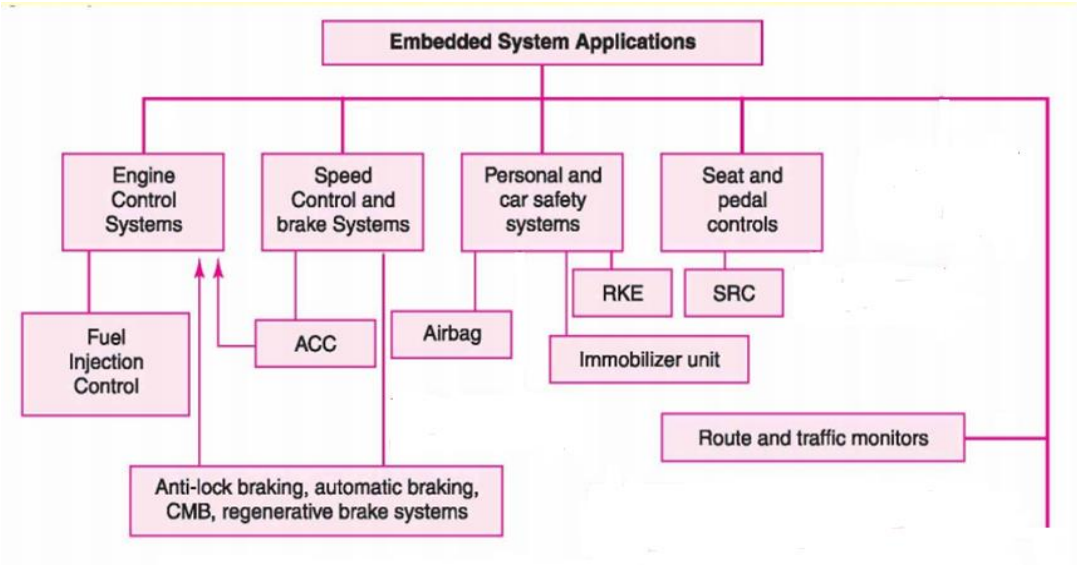
- ABS maintains the vehicle's steerability and stability during panic braking.
- It can also be controlled on wet surfaces.

Disadvantages:

- Perhaps the only disadvantage of the Antilock Braking System is its higher cost. In recent times, purchasing the Antilock Braking System installed car costs significantly to the customer. However, this higher cost is completely offset by the improved safety this system provides.

Case study of Adaptive Cruise control system(ACC)

Def: Adaptive cruise control (ACC) is a driver assistance technology that sets a maximum speed for vehicles and automatically slows the speed of the car when traffic is sensed in front of the vehicle.



Advantages of ACC:

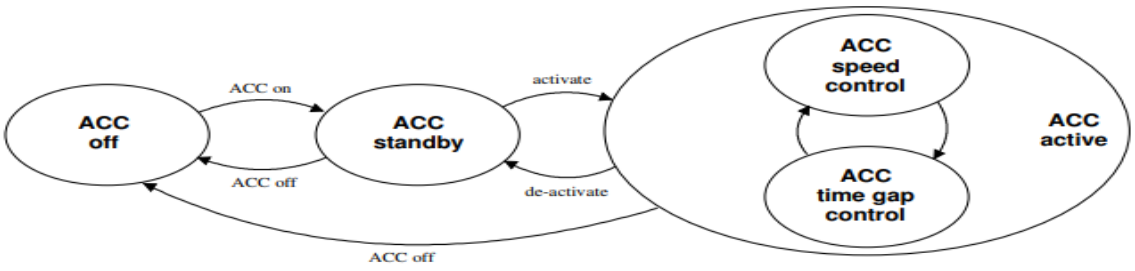
- **Relax on the Road:** One of the primary advantages is that it allows drivers to maintain the same speed without having to keep their right foot on the pedal. This allows the driver to relax, something that is very beneficial, especially during a long road trip.
- **Safety Over Speed:** Cruise control also helps reduce the driver's tendency to speed, which can help increase safety and decrease the likelihood of accidents.

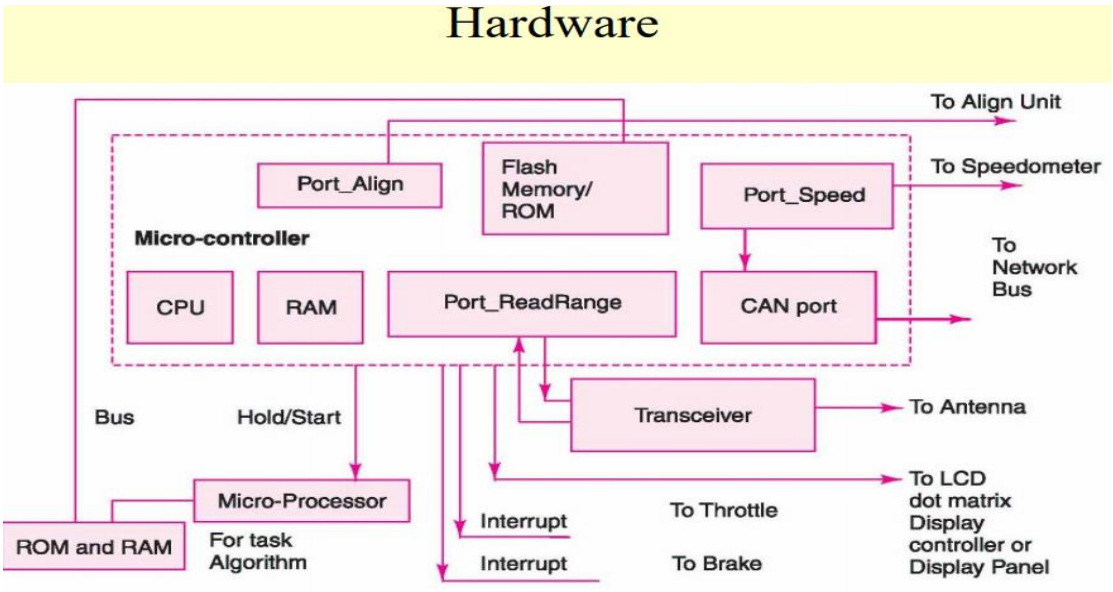
Disadvantages:

- High Cost
- Not for Heavy traffic
- Encourages the driver to become careless

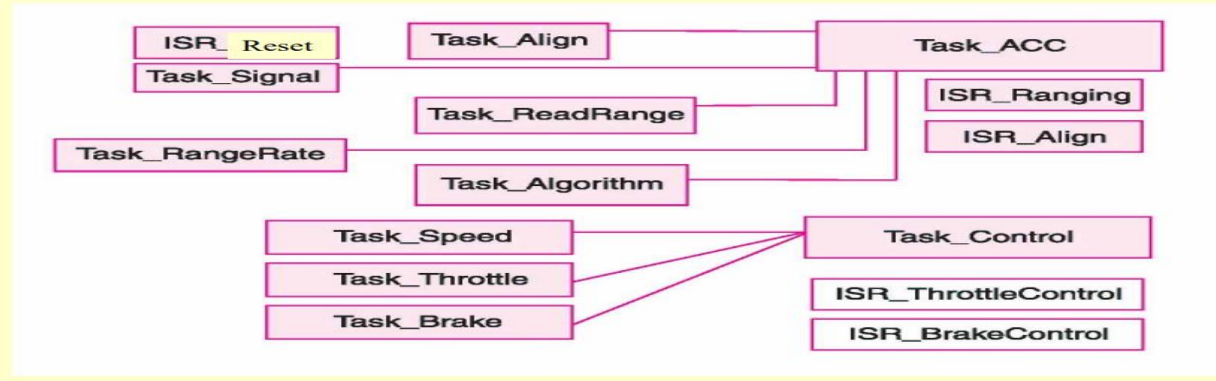
System states:

- **ACC off state** – direct access to the 'ACC active' state is disabled.
- **ACC standby state** – system is ready for activation by the driver.
- **ACC active state** – the ACC system is in active control of the vehicle's speed.
- **ACC speed control state** – a substate of 'ACC active' state in which no forward vehicles are present such that the ACC system is controlling vehicle speed to the 'set speed' as is typical with conventional cruise control systems.
- **ACC time gap control state** –The time gap between the ACC vehicle and the target vehicle is being controlled





- A hardware system in automotive electronics has to provide functional safety. A microcontroller runs the tasks and ISRs except task_Algorithm. Internal RAM/ROM, ROM/Flash for RTOS codes for scheduling the tasks.
- CAN port interfaces with the CAN bus at the car. A separate processor with RAM and ROM for the task Algorithm executes the adaptive control algorithm. Speedometer- Indicating the speed.
- Transceiver for transmitting pulses through an antenna hidden under the plastic plates. LCD dot matrix display controller, display panel with buttons



- Task alignment: The cycle starts from the task.
- Task Read range: the port activates a Radar and gets the time of sensing the reflected radar signal and finds the time difference. Task speed: speed to start a timer, for the number of wheel rotations.
- Task range rate: it calculates the range now from the time difference. Get the cruise speed and compare it with the current speed. Task algorithm: execute an adaptive algorithm. Send an signal to the port_ Brake incase of emergency braking action needed.

Case study of an Embedded system for a Smart card

Def: It is typically a plastic card with an embedded integrated circuit(IC) chip. Used as payment cards like credit/debit cards. Hospitals uses these cards to store the patient details.

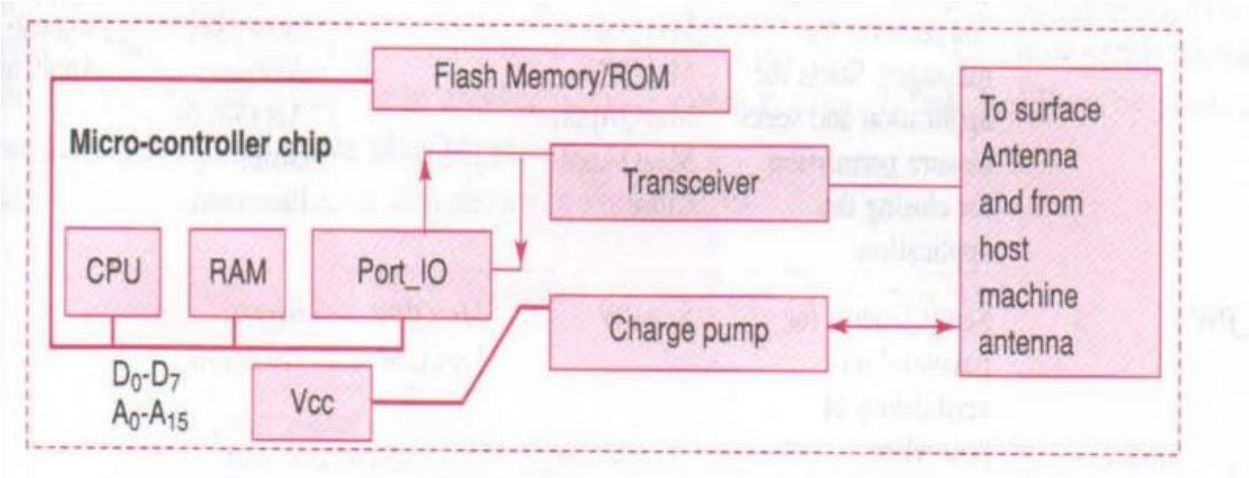
- Smart card is one of the most used embedded system today. A magnetic stripe card is any type of card that contains data embedded in a strip. The front of the card contains identifying information, such as the cardholder's name and the issuing company's name.
- Chip cards have a little silver or gold microchip embedded on the front of a debit or credit card. Just like the magnetic stripe, the chip contains information about the account(s) associated with the card.

How chip card works:

- Smart card stores and process information through electronic circuits embedded in the silicon in a plastic substrate body. The chip contains information about the account associated with the card. In order to use the chip card, the cardholder inserts the card into a chip-enabled terminal such as an ATM or a point-of-sale (POS) terminal.
- The terminal submits the cardholder's information to the merchant or card provider's site. If the account balance supports the transaction, it is then approved. If not, the terminal rejects the transaction and it does not go through. Some terminals require the cardholder to enter a personal identification number (PIN) or a signature to complete the transaction.

Embedded Hardware:

The microcontroller used is MC68HC11 or PIC16C84 which has 8Kb internal RAM and 32kb EEPROM/flash . Most cards use 8 bit cpus. The recent introduction cards is of a 32 bit RISC cpu.



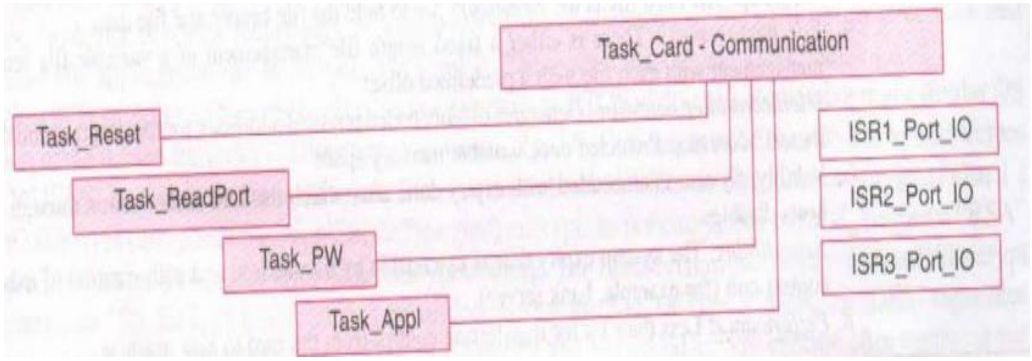
System functioning:

- When card is inserted at the host machine . The radiations from the host machine activate the charge pump at the card. The charge pump powers the SOC circuit, which consists of card processor, memory, transceiver and I/O port. Input/output: transmit and receive messages at port I/O.
- These controllers can be best understood as the messenger that facilitates communication between the user and the cardholder's bank and perform transactions. Transrecevier for read and write i,e to send information or receive information from the bank. The surface antenna and host machine antenna from where you will be getting the data.
- As card details of a person has to be authenticated, information about his/her bank account has to be fetched from bank server and then at last information has to be updated on the server after some transaction. So communication is required for all this.

Embedded Hardware Components:

- Microcontroller
- ROM for application codes and RTOS codes for scheduling the tasks.
- Flash for storing the card user information, card number, expiry date and personal Identification Number.
- Card user data, for example name, bank and branch identification number and account number.
- Interfacing circuit for the IOs.
- Charge pumps for delivering power to the antenna for transmission and for the system circuits.

EMBEDDED SOFTWARE COMPONENTS



Reset task: it is the task that executes like the first task.. It creates the three tasks,
Task_ read port: reads the card for the authorization of the user.
Task _PW: The task password will send through the IO port in order to identify the user at the host.
Task_APPL : Print mini statement of bank account, eject the cash from the host, request for print of this transaction.

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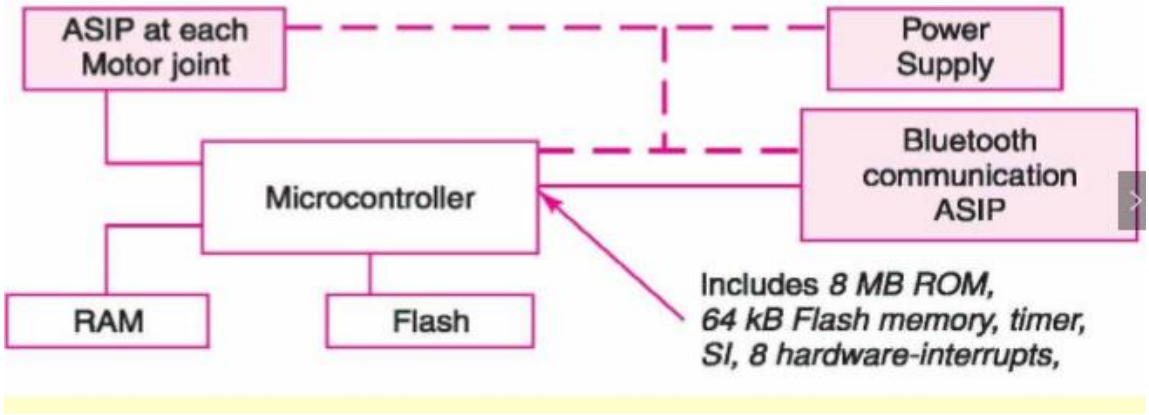
Case study of communication between Orchestra Robots

- QRIO ("Quest for cuRIOsity", originally named Sony Dream Robot or SDR) was a bipedal humanoid entertainment robot developed and marketed (but never sold) by Sony . QRIO stood approximately 0.6 m (2 feet) tall and weighed 7.3 kg (16 pounds). QRIO's slogan was "Makes life fun, makes you happy!“
- Qrio is a small entertainment humanoid that can hear, speak, sing, walk, run, dance, recognize faces, and grasp objects. It was exceptionally advanced for its time, and sadly it was canceled in 2006.
  - Interact with humans with movements
  - Speech with more than 1000 words
  - Learn new words also
  - Showed emotions by flashing lights

Hardware architecture

- A microcontroller at master and each slave to control for Orchestrator for movements.
- An ASIP for each motor movement.
- An ASIP at master and each slave for Bluetooth piconet communication between master and slaves.
  - Processors
  - ASIPs
  - Memory
  - Ports.

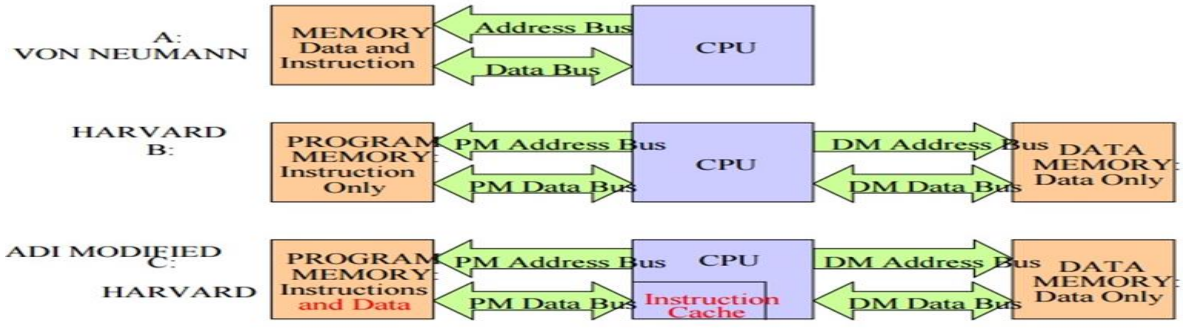


Program Module Orchestrator-1 at a microcontroller 1 with k sensor inputs and q outputs to actuators and p outputs to message boxes

- Inputs and Outputs to a software module
- k sensor inputs to a module, q outputs generate to actuators in a sequence.
- p outputs to message boxes (also called mailboxes in certain OSes or notifications in certain OSes) in a sequence .
- Software which sequences synchronizes the inputs from 1st to kth sensors and generates the messages and outputs for the actuators, display and message boxes at the specified instances and time intervals. message boxes store the notifications, which initiate the tasks as per the notifications

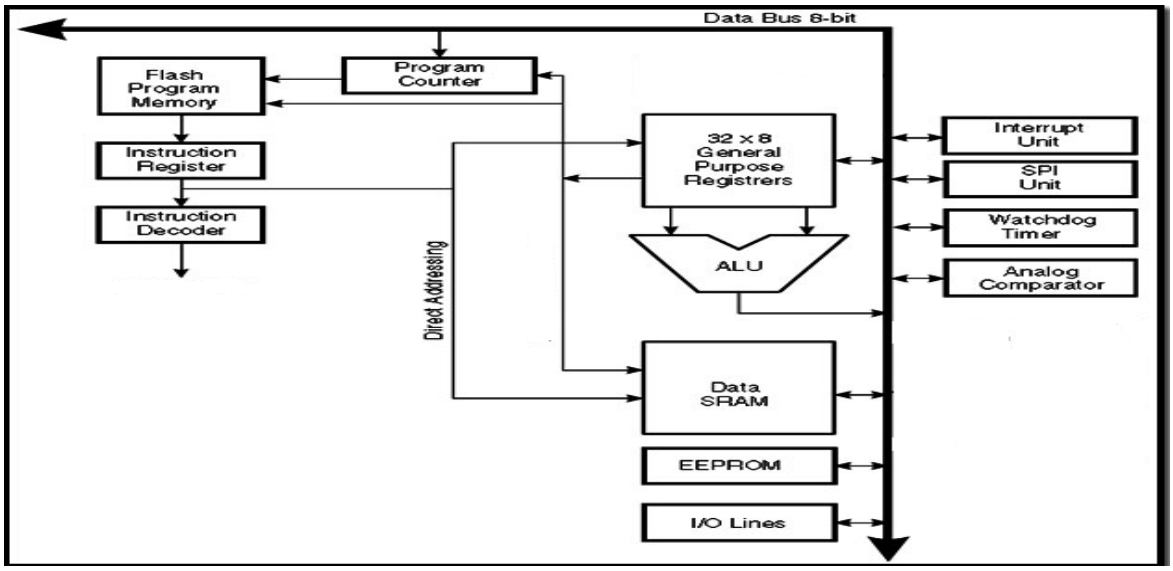
AVR FAMILY OF MICROCONTROLLER (ATMEGA 8)

- AVR is a family of microcontrollers developed by Atmel beginning in 1996.
- AVR stands for Advanced Virtual RISC and it is a microcontroller with variety of peripherals such as Timers, memory, serial data communications, Inputs & output units programmable on a single chip. These are modified Harvard architecture 8-bit RISC single-chip microcontrollers.
- There are different configurations of AVR Such as 8 bit, 16 bit and 32 bit. The Atmel AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle.



How to Use ATMEGA8 Microcontroller

- Using ATMega8 is similar to other ATMega microcontrollers, such as ATMega32. Similarly, the micro-controller need to be programmed and added appropriate peripherals to get the output. Without programming the controller is an empty chip.
- For working of ATMEGA8, first we need to burn the appropriate program file in the ATMEGA8 FLASH memory. After dumping this program code, the controller executes this code and provides appropriate response



Features of ATMEGA8 Microcontroller(28 PIN Dual inline package)

- Advanced RISC Architecture
- Powerful Instructions – Most Single-clock Cycle Execution
- 32 × 8 General Purpose Working Registers
- Operates with 16MHz
- 8Kbytes of Flash program memory
- 512Bytes EEPROM
- 1Kbyte Internal SRAM
- Two 8-bit Timer/Counters
- Two-wire Serial Interface(I2C Bus)
- Programmable Serial USART

Memory section:

- Flash memory is a long-life and non-volatile storage chip that is widely used in embedded systems. It is used to store the program information even when the power is off.
- SRAM keeps data constant, without the need for the memory to be refreshed periodically. Consequently, SRAM modules grant faster data access than DRAM ones. This is why SRAM is used for applications that require relatively fast access to data, like video cards and cache memory.
- EEPROM stands for electrically erasable programmable read-only memory and is a type of non-volatile memory used in computers, integrated in microcontrollers devices to store relatively small amounts of data.

ALU SECTION:

- The high performance ALU operates directly with all 32 general purpose registers. With a single cycle, arithmetic operations between general purpose registers are executed.

Interrupt:

- An interrupt is a signal to the processor emitted by hardware or software indicating an event that needs immediate attention. Whenever an interrupt occurs, the controller completes the execution of the current instruction and starts the execution of an Interrupt Service Routine (ISR) or Interrupt Handler

SPI (Serial Peripheral interface): ATmega8 holds three communication devices integrated. One of them is Serial Peripheral Interface. Four pins are assigned to Atmega8 to implement this scheme of communication.

- The serial peripheral interface (SPI) is one of the most widely used interfaces between microcontroller and peripheral ICs such as sensors, ADCs, DACs.

TWI (Two Wire Interface): Another communication device that is present in ATmega8 is Two Wire Interface. It allows designers to set up a commutation between two devices using just two wires along with a common ground connection.

Analog Comparator: A comparator module is integrated in the IC that provides comparison facility between two voltages connected to the two inputs of the Analog comparator via External pins attached to the micro controller.

Analog to Digital Converter: Inbuilt analog to digital converter can convert an analog input signal into digital data. Because most of the data available in real world is analog in nature, hence to process them they need to be converted in to digital.