S. No.	Date	Title	Page No.	Teacher's Sign / Remarks

chapter 1

Overview of Embedded System

An embedded system can be defined as a computing device that does a specific focused job.
Appliances such as air conditioner, DCD player, DVD player, printer, fax machine, mobile phone, etc... are examples of embedded system. Each of these appliances will have a processor and special hardware to meet the specific requirement of the application along with the embedded software that is executed by the processor for meeting specific requirement. The embedded software is called firmware.
Embedded systems are classified or characterized by some special features:

1) They do a very specific job, they cannot be programmed to do different things.
2) Embedded systems has very limited resources particularly the memory, generally they do not have secondary storage devices such as CD-ROM.
3) Embedded system have to work against some deadline A specific job has to be completed within the specific time in some embedded systems called real time systems. The deadlines are stringent. Missing a deadline may cause catastrophe.
4) Embedded system are constraint for power. As many embedded systems operate through the battery, the power consumption has to be very low.
5) Embedded system needs to be highly reliable.
6) Some embedded systems have to operate in extreme environment conditions such as high

temperature and humidity.
4) Embedded systems that address the consumer market (toys) are very cost sensitive even the reduction of $0.1 is lot of cost of saving because 1000 or millios systems may be sold.

Application areas

1) Consumer Appliances:
-At home we use number of embedded system which includes digital camera, digital diary, electronic toy, microwave oven, AC's, video game control, etc... Today ITECH car has almost 20 embedded systems for transmission control, engine apart control and navigation. Even wrist watches are now becoming embedded.

2) Office Automation:
-The office automation product using embedded system are copying machine, fax machine, printers, scanners, etc.

3) Industrial Automation:
-Lot of industries we use embedded system for process control. The embedded system for industrial use are designed to carry out specific task such as monitoring, temperature, pressure, humidity, voltage, current, etc... and then take appropriate action based on the monitored levels to control other devices or to send information to centralized monitoring station. In hazardious industrial environment where human presence has to be avoided, robots are used which are prsgrammed to do specific job

4) Medical Electronics:
-Almost every medical instruments in hospital is an embedded system. This equipment includes ECG, EEG, blood pressure measuring device, X-ray and equipment used in blood analysis, radiation, engioscopy, etc...

5) Telecommunication:
-The embedded system can be categorised as terminals and network equipments.
-The terminals such as keyfete, ISDN and phones, web cameras are embedded system.
-The network equipments include multiplexers, packet assembler Deassembler, Sattelite modem.
-IP phone, IP gateway are latest embedded system that provides very low cost voice communication.

6) Instrumentation:
-Testing and measurement are fundamental requirements in all scientific activities.
-The measuring equipments that we use in laboratories to measure parameter such as weight, temperature, pressure, humidity, voltage, current, etc... are all embedded system.

7) Finance:
-Financial dealings through cash and cheques has minimized over a period of time as the transaction has been carried out as a Smart card and ATM. Smartcard of the size of credit card has a small microcontroller and memory and it interacts with the ATM machine.

Categories of Embedded System

Embedded system can be categorised as:

1) Standalone Embedded Systems

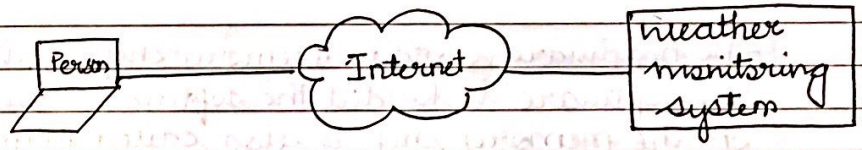
- It takes the input and gives the desired output. after carrying the processing.
- standalone system works in standalone mode. They take input, process them and produce desired output.
- They can be or electrical signal like pressing a button.
- The output could be electrical signal to drive another system or LED/LCD display for displaying of information to user.
- Consumer Electronic item fall into this category.
- In the process control system the inputs are from user that converts physical entity like pressure into its equivalent electrical signal. These electrical signals are processed by the systems and appropriate electrical signal is produced using which an action is performed.
- Ex: Camera, microwave oven, CD player, TV, etc...

2) Real time systems

- Embedded system in which some specific work has to be done in a specific time period are called real-time.
- For example consider a system that has to open a valve within 30ms when humidity crashes certain treshold. If the valve doesn't open within 30ms the Catastrophe may occur. Such systems are called real-time system.
- In some systems such as DVD player, after giving a command to the DVD player from remote control, there is a delay in executing this command but this delay won't delay serious applications. Such applications are called real-time systems.

3) Network Information Appliances.

- Embedded systems that are provided with network interfaces and accessed by networks such as LAN's or Internet are called Network Information Appliance.
- Such embedded system are connected to a network and uses TCP/IP protocol and get connected through Ethernet through a network and communicate to other nodes.



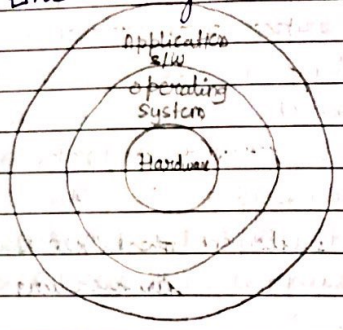
- Ex: The door lock of your home can be small embedded system where TCP/IP and STP is working. When someone stands near doorlock, the web camera will send an alert to desktop over the internet and then you can open door lock at click of your mouse
- Any computer connected to internet can access this system to obtain real time application.

4) Mobile Devices.

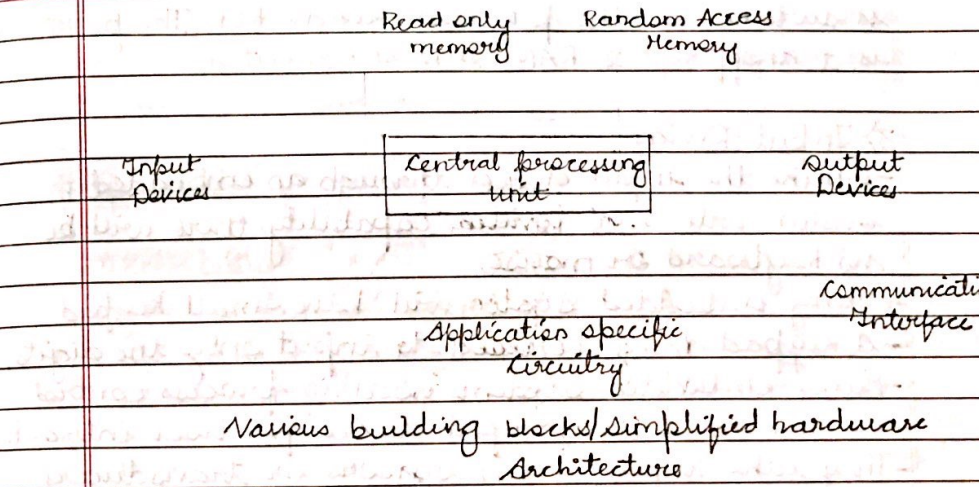
- Mobile devices are the device such as mobile phones, smart phones, etc... are a special category of embedded system.
- The limitations of mobile devices are memory constraint,

small sizes, lack of good user interfaces such as full flash keyboard and display. Hence mobile devices are considered as embedded system.

Overview of Embedded System Architecture



- The hardware contains memory chips onto which the software is loaded. The software residing on the memory chip is also called firmware.
- The embedded system architecture can be represented as normal architecture and the applications run above operating system.
- It is not compulsory to have operating system in all operating system in appliances such as AC, toys, etc... There is no need of an operating system.
- You can write only the software specific to that application.
- For applications involving complex processing it is advisable to have an operating system. In that case one need to integrate the application software with the operating system and then transfer the entire software on to the memory chip.



Various building blocks/simplified hardware Architecture

1) central processing unit
- It can be any of the following microcontroller, microprocessor and DSP.
- A microcontroller is a low cost processor, its main attraction is on chip itself. They will be many other components such as memory, serial communication interface, A to D, etc.. For the small application microcontroller is the best choice as the number of external components required is very less.
- On the other hand microprocessor are more powerful but use external components.

2) Memory
- The memory is categorised as RAM and ROM, the content of RAM will be erased if power is switched off whereas ROM retains the content even if power is switched off.
- So the firmware is stored in the ROM when power

is switched on, the processor reads ROM, The program is transffered to RAM and is executed.

3) Input Devices
- Unlike the input devices through an embedded system will have limited capability, there will be no keyboard or mouse.
- Many embedded system will have small keypad.
- A keypad may be used to input only the digits.
- Many embedded systems used in process control do not have any input device for user interaction
- They take input from sensors or transducers. which produce electrical signals that are in turn fed to another system.

4) Output Devices
- The output devices of embedded system also have very limited capability. Some embedded system will have LED to indicate status of the module or for visual indication of alarms.

5) Communication Interfaces
- The embedded system may need to interact with other embedded system where they might have to transmit data to a desktop.
- To facilitate this embedded systems are provided with few communication interfaces such as RS-232, RS-422, RS-485, USB, Ethernet, etc...

6) Application specific Circuitry
- Sensors, transducers, special processing and control circuitery may be required for an embedded system depending on its application.
- This circuitry involves with the processor to carry out certain work.

Specialities of Embedded System

1) Reliability
- If we use a desktop system and if the system hangs we need to reset the computer. Generally it do not cause any problem. However this is not the case with the embedded system. They must work with high reliability.
- Reliability is of paramount importance in embedded system. They should continue to work for thousands of hour without break.
- So design of the embedded system should be such that in the case the system has to be in a way that reset should be done automatically.
- Special hardware and software to be used to take care of it.

2) Performance
- Many embedded systems have time constraints for example in a process control system if the temperature exceeds 40° open a valve within 10ms. The.
- The system must meet such deadlines.
- If the deadlines are met, it may result in catastrophe.

3) Power Consumption
- Most of the embedded system operate through battery.
- To reduce battery drain and frequent recharging

of battery the power consumption of the embedded should be build in a way and to reduce the power consumption, such hardware components should be used that use less power.
-To reduce the components count, the hardware designer have option to use PLD's and FPGA.

4) cost
-For most embedded system used in safety applications of a nuclear plant or spacecraft, cost may be a very important factor.
-By careful analysis of design, one can find a way to reduce the cost.
-For example: Consumer electronics such as toys.
-Suppose you design a toy and was able to reduce the cost by 1 rupee and when millions of toys are produced this reduction is in millions of rupees.

5) Size
-It is certainly a factor for many applications.
-We definitely do not like a mobile phone to be carried in our bag. The size and weight are important parameters used in space craft, missiles, etc...
-The hardware engineer have to design their board to design the component count to minimise size and weight.

6) Limited user Interface:
-Embedded system do not have sophisticated interface for input and output.
-They take electrical signals as input and produce electrical signals as output.
-Developing a user friendly interface with limitation of input output devices is a challenging task for firmware developer.

7) Software upgradation capability
-Embedded systems are made for very specific task so and the software is transffered through the operating system, the same will run throughout.
-However in some cases it may to necessary to upgrade the software.
-In these days the software upgradation is done by downloading the software on the embedded system the network connection.

Recent trend in Embedded System

1) Processor power:
-The processor power can be ganged by availability of processors.
- Powerful 8 bit, 16 bit, 32 bit microcontroller and microprocessor are available to tattle to market segment.
-The clock and memory addressing capacity of this processes are increasing.

2) Memory:
-The cost of the memory is reducing day by day as a result the embedded system can be functionality can be reached by incorporating networking features like networking protocol and user interfaces.
-

3) Operating System
- Variety of operating systems are available which can be ported to operating system.
- The advantage of embedding an operating system is that the software development will be varifying and maintaining the code is very easy
- The software can be developed in high level language.

4) Communication Interfaces and Networking capabilities.
- The availability of low cost chips, embedded system can be provided with networking capabilities through common interfaces like Ethernet, 802.11 wireless LAN which has led to many enterfaces such as it can be accessed over network. For example: weather monitoring.

5) Programmable Hardware
- PLD's and FPGA's paid the way for reducing components on an embedded system, leading to small and low cost resources.

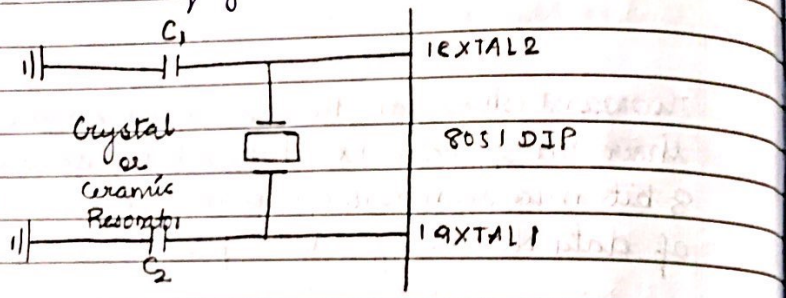
architecture block diagram of microcontroller

Microcontrollers can be classified on the basis of their bit process. Ex: 8 bit, 16 bit microcontroller. 8 bit microcontroller means it can read/write 8 bits of data. Normally 8 bit represent size of databus.

Major Features of 8051
- 8 bit CPU with registers A and B
- On chip oscillator
- 4k bytes of on chip ROM (internal ROM 0-4K)
- 128 bytes of on chip RAM (internal RAM): 4 register banks, each containing 8 registers
- 21 special function registers
- 16 bit program counter (PC) and data pointer (DPTR)
- 8 bit program status word (PSW)
- 8 bit stack pointer (SP)
- 16 bytes which may be addressed at bit and 80 bytes of general purpose byte memory.
- 32 input/output pins arranged as four 8 bit ports: P0-P3
- Two 16-bit timer/counter: T0 and T1
- Full duplex serial data reciever/transmitter: SBUF
- Control registers: TCON, TMOD, SCON, PCON, IP and IE.
- Two external and three internal

* Oscillator and Clock
- The heart of 8051 is the circuitry that generates the clock pulses, by which all the internal operations are synchronized.
- Pin XTAL1 and XTAL2 are provided to form an Oscillator.
- A quartz crystal and capacitor are employed

as shown in the figure



-The crystal frequency is a basic clock frequency of the microscontroller.
-Program instruction may require one, two or four machine cycle depending on type of instruction
-Instructions are fetched and executed by the microscontroller automatically beginning with the instruction located at address 0000H at the time the microscontroller is first reset.

* Program Counter and Data Pointers
-8051 contains 2 16 bit registers, this is used to hold address of byte in memory.
-Program instruction bytes are fetched from locations in memory that are addressed by the program counter. The program counter PC is automatically incremented after every instruction byte is fetched. The PC is the only register that does not have an internal address.
-DPTR is made up of two 8 bit register which are used to furnish memory addresses for internal and external code access. DPTR does not have single internal address but DPH or DPL are each assigned an address.

* A and B CPU Register
-8051 contains 34 general purpose registers, two of them are A and B which holds many instructions like math and logical operations.

* Flags and Program Status Word
-8051 has four math flags that can be set to 1 or cleared to 0 by the programmer as desired.
-The math flags includes carry(C), auxillary carry (AC), overflow(OV) and parity(P).
-The user flags are named F0. Note that all the flags can set or cleared by programmer on will.
-The math flag however are also affected by math operation.

7	6	5	4	3	2	1	0
CY	AC	F0	RS1	RS0	OV	–	P

with the function

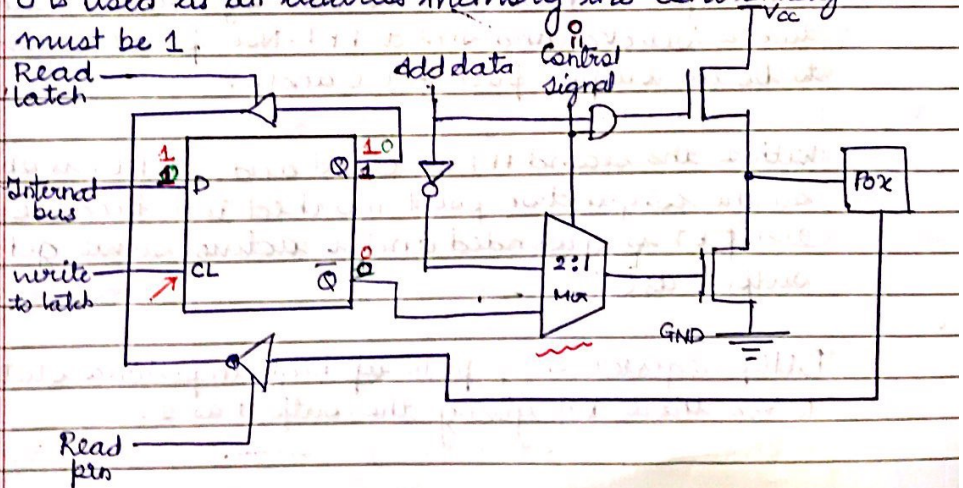
* Internal RAM
- The 128 byte internal RAM is organized into three distinct areas.
- 32 bytes from address 00H to 1FH. (Register Bank)
- Bit addressable area of 16 byte occupies RAM byte addresses 20H to 2FH forming total of 128 addressable bits.
- A general purpose RAM area above bit area from 30H to 7FH addressable as bytes.

* The stack and the stack pointer
- The stack refers to the area of internal RAM that is used with certain opcode to store and retrieve data quickly.
- The 8 bit stack pointer is used to hold internal RAM address that is called the top of the stack. The address held in SP register is the location in internal RAM where the last byte of data was stored.
- When the data needs to be stored on stack the SP increements before storing the data so that stack grows up when data is stored.
- When the byte is read from the stack, the SP decreements to point to the next available byte.

* Special function Registers
- They uses registers from 80H to FFH.
- Some FSR's marked with an asterick are also bit addressable which allows programmer to change only what is required remaining.

* Internal ROM
- The Internal ROM occupies part address space 0000H to 0FFFH.
- If the program addresses are higher than 0FFFH which exceeds the internal ROM capacity will cause 8051 to automatically fetch codes, bytes from external program memory.

* Input/Output pins, ports and circuits.
- One of the major feature of microcontroller is built into the input output circuits that connect 8051 to the outside world.
- Port 0:
→ port 0 pins may serve as input, output, or when used together as a bidirectional low order address and databus for external memory.
→ For example when a pin has to be used as an input a 1 must be written to the corresponding port 0. by the program.
→ When used as a output a 0 must be written, when port 0 is used as an address memory the control signal must be 1.



For input/output control signal has to be zero. And it has to

When we enable the latch we get 1 at Q and 0 at Q bar as

As control signal is zero it allows the mux to choose second input connected to it as Q bar and output is 0.

Now here the FET gets 0, so it is called as open circuit, so when its open FET does not allow anything to pass through. And that point is called as high impedance state because its neither 0 nor 1

Now port 0 is ready to accept as input, if input is 0 then it will overwrite the high impedance state and can be read through buffer

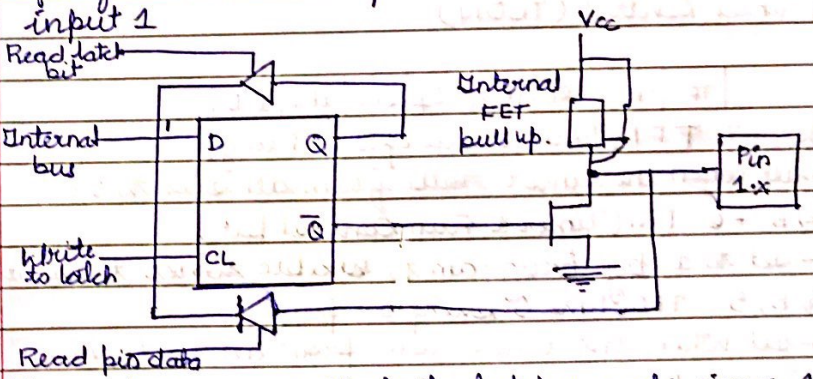
First write 0 to latch, enable latch so Q is 0 and Q bar is 1. 1 goes to mux and control logic is 0 so same line is selected and sent to FET. Now port 0 is ready to be an output port for 0 and 1.

With 1 the second FET is closed and 1st FET is open, so the conjunction point marked is 0 because 2nd FET is grounded and is active, so we get output as 0.

Pull Up register only pulls up high impedance state to Vcc there by giving the output as 1.

Part 1:

- Port 1 pins have no dual functions. Therefore the output of latch is connected directly to the gate of the lower FET. which has an ~~active~~ FET circuit labelled FET pull-up. Pull-up is used as an input, a 1 is returned to latch turning a lower FET off. the pin and input to pin buffer are pulled high to pin load.
- The external circuit can overcome high impedance ~~plug~~ plug and draw a pin low to input 0 and leave input 1



If used as an output, the latches containing 1, can drive the input of an external circuit high through the pull-up. If the 0 is return to the latch the lower FET is on, the pull up is off and the pin can drive the input of external circuit location.

Port 2:

- It may be used as input/output similar to operation of port 1.
- The alternative to port 2 is to supply higher order input with the port 0 lower order input into address internal memory.

Port 3:
It is an input/output similar to port 1. The input and the output functions can be programmed under the control of P3 latches or under the control of various other special functions registers.

Timer modes of operations
- The timer may operate in any one of four modes that are determined by the mode bits m1 and m0 in the TMOD registers.

1. Timer Control (TCON)

TF1	TR1	TR0	TR0	IE1	IT1	IE0	IT0

1) B; +7 TF1 (Timer 1 overflow Flag)
- set when the timer rolls from all ones to 0's.
2) B; +6 TR1 (Timer 1 Run Control bit)
- set to 1 by program to enable timer to count.
3) B; 5 TF0 (Timer 0 overflow flag)
- set when the timer rolls from all 1's to 0's
4) B:4 TR0 (Timer 0 run control bit)
- set to 1 by program to enable timer to count
5) B:3 IE1 (External Interrupt 1)
- It is set to 1 when high to voltage/edge signal is recieved on port 3 (pin 3.3)
6) B:2 IT1 (External Interrupt 1 signal type control bit)
- It is set to 1 by program to enable external interrupt 1 to be triggered by falling edge signal and set to 0 by program to enable a low level signal or external interrupt 1 to generate an interrupt.
7) B:1 IE0 (External Interrupt 0)
- set to 1 when high to low edge signal is recieved on port 3 (pin 3.2)
8) B:0 IT0 (External Interrupt 0 signal type control bit)
- set to 1 by program to enable external interrupt 0 to be triggered by falling edge signal.
- set to 0 by programs to enable the low level signal or external interrupt 0 to generate an interrupt.

TCON register is bit addressable as TCON.0 to TCON.7

Expt 2: 1

Aim: Basic 8051 programming

aim: To study instruction set, addressing mode and basic programming use keil IDE.

THEORY:

1) Basic features of 8051 microcontroller (9-10)
2) Draw the programming model of 8051.
3) Addressing modes of 8051
4) Program Status word register.