UNIT-2

TYPICAL EMBEDDED SYSTEMS

CONTENTS

2.1. Core of the Embedded System

a) General purpose and domain specific Processors

b) ASICs

c) PLDs

d) COTs

2.2. Memory

a) ROM

b) RAM

c) Memory according to type of interface

d) Memory shadowing

e) Memory selection for Embedded system

2.3. Sensors and Actuators

2.4. Communication Interface

2.1. CORE OF THE EMBEDDED SYSTEMS

- ✓ Embedded systems are domain specific and application specific and are built around a central core.
- ✓ The core of the embedded system falls into any of the following categories

  a) General purpose & Domain specific

  b) ASICs

  c) PLDs

  d) COTs

2.1(a) General purpose & Domain specific processors

- Almost embedded systems are processor/ controller based. The processor may be

  i) Microprocessor

  ii) Microcontroller

  iii) Digital Signal Processor

i) MICROPROCESSOR

- A microprocessor is a silicon chip representing a CPU, which is capable of performing arithmetic and logical operations according to pre-defined set of instructions.
- In general, CPU contains ALU, control unit and working registers.
- A Microprocessor is a dependent unit and it requires the combination units like memory, timer, and interrupt controller etc for proper functioning.

4004 processor

- designed by INTEL in 1971
- It is 4-bit processor
- 1K Data memory
- 12-bit program counter
- 4k Program memory
- Sixteen 4-bit general purpose registers
- 46 instructions
- Clock speed is 740 KHz

4040 processor

- Designed by INTEL in 1972
- Program space is 8K
- 60 instructions

8008 processor

- Designed by INTEL in April 1972
- 14 bit program counter

8080 processor

- Designed by INTEL in April 1974
- 8-bit processor
- 16-bit address bus and program counter
- Seven 8-bit registers

8085 processor

- Designed by INTEL in 1976
- 8-bit processor
- 3 interrupt pins
- Built– in clock generator and controller circuits
- +5V power supply

Intel,AMD,Freescale,IBM,Cytrix,Hitachi,NEC, LSI Logic etc. are key players in microprocessor market

ii) MICROCONTROLLER

- A Microcontroller is highly integrated chip that contains CPU, scratchpad RAM, special and general purpose register arrays, on chip ROM, timer and interrupt control units and dedicated I/O ports
- Texas instruments's TMS 1000 is considered as the world's first microcontroller.
- TI followed INTEL's 4004/4040 design and added some amount of RAM, ROM and I/O support on a single chip.

- In 1977, INTEL entered the microcontroller market with a family of controllers coming under one umbrella named MCS-48.
- Under this family, the processors were 8038HL, 8039HL, 8040AHL, 8048H, 8049H and 8050AH.
- INTEL 8048 is recognised as INTEL's first microcontroller.
- Eventually INTEL came out with its most fruitful design in the 8-bit microcontroller domain- the 8051 family and its derivatives.

- It is the most popular and powerful 8-bit microcontroller ever built. Almost 75% of the microcontrollers used in the embedded domain were 8051 family based microcontrollers during 1980-90s.
- Another important family of microcontrollers used in industrial control and embedded applications is the PIC family microcontrollers from Microchip Technologies.
- Due to performance and computational needs demand 16/32 bit microcontrollers

- Infineon,Freescale,Philips,Atmel,Maxim,Micro chip etc. are the key suppliers of 16-bit microcontrollers.
- Freescale, NEC, Zilog, Hitachi, Mitsubishi, Infineon, ST Micro Electronics, National, Texas Instruments, Toshiba, Philips, Microchip, Analog devices, Daewoo, Intel, Maxim, Sharp, Silicon Laboratories, TDK, Triscend, Winbond, Atmel,etc. are the key players in the microcontroller market.

iii) DIGITAL SIGNAL PROCESSORS

- DSPs are powerful special purpose 8/16/32 bit microprocessors designed specifically to meet the computational demands and power constraints of today's embedded audio, video, and communication applications.

- DSPs are 2 to 3 times faster than general purpose microprocessors in signal processing applications.

2.1(b) ASICs

- ASIC stands for Application specific integrated circuit.
- ASIC is a microchip designed to perform a specific or unique application.
- It is used as replacement to conventional general purpose logic chips.

- It integrates several functions into a single chip and there by reduces the system development cost.
- As a single chip, ASIC consumes a very small area in the total system, and thereby helps in the design of smaller systems with high capabilities/functionalities.
- ASIC can be pre-fabricated for a special application or it can be custom fabricated by using the components from a re-usable ‘building block’ library of a components for a particular customer application.

- Fabrication of ASICs requires a non-refundable initial investment for the process technology and configuration expenses.

- This investment is known as "Non-Recurring Engineering(NRE)" charge. And it is one time investment.

2.1(c) PLDs

- Logic devices provide specific functions, including device-to-device interfacing, data communication, signal processing, data display, timing and control operations.

- Logic devices can be classified into two broad categories – fixed and programmable.

- As the name indicates, the circuits in a fixed logic device are permanent, and they perform one function or set of functions- once manufactured, they cant be changed.
- On the other hand, Programmable Logic Devices(PLDs) offer customers a wide range of logic capacity, features, speed, and voltage characteristics- and these can be re-configured to perform any number of functions at any time.
- With a PLDs, designers use inexpensive software tools to quickly develop, simulate, and test their designs.

CPLDs and FPGAs

- The two major types of PLDs are FPGAs and CPLDs.

- Of the two, FPGAs offer the highest amount of logic density, most features, and highest performance.

- Example for FPGA is, Xilinx Virtex line of devices, provides 8 million 'system gates'.

- FPGAs are used in a wide variety of applications ranging from data processing and storage, to instrumentation, telecommunications, and digital signal processing.

- ✓ CPLDs offers much smaller amounts of logic- up to about 10000 gates.

- ✓ Example is, Xilinx CoolRunner series, also requires low power, inexpensive, low cost, battery operated, portable applications such as mobile phones and digital handheld assistants

Advanteges of PLD

❖PLDs offer a number of important advantages over fixed logic devices, including:

i) More flexible

ii) Do not require long lead times for production

iii) No NRE cost

iv) PLDS allow customers to order just the number of parts they need, when they need them.

2.1(d) COTS

- A commercial off-the-shelf components are designed in a such a way to provide easy integration and interoperability with existing system components.

- The COTS component itself may be developed around a general purpose or domain specific processor or an Application specific integrated circuit or programmable logic device.

- Typical examples of COTS hardware unit are remote controlled toy car control units including the RF circuitry part, High performance, high frequency microwave electronics, high bandwidth analog-to-digital converters, devices and component for operation at very high temperatures, electro-optic IR imaging arrays, UV/IR detectors.
- The major advantage of using COTS is that they are readily available in the market.

2.2. MEMORY

- Memory is an important part of a processor/ controller based embedded systems. Some processors/controllers contain built in memory and this memory is referred as ‘On-Chip memory’.
- Others do not contain any memory inside the chip and requires external memory to be connected with controller/processor is called ‘Off-Chip Memory’.

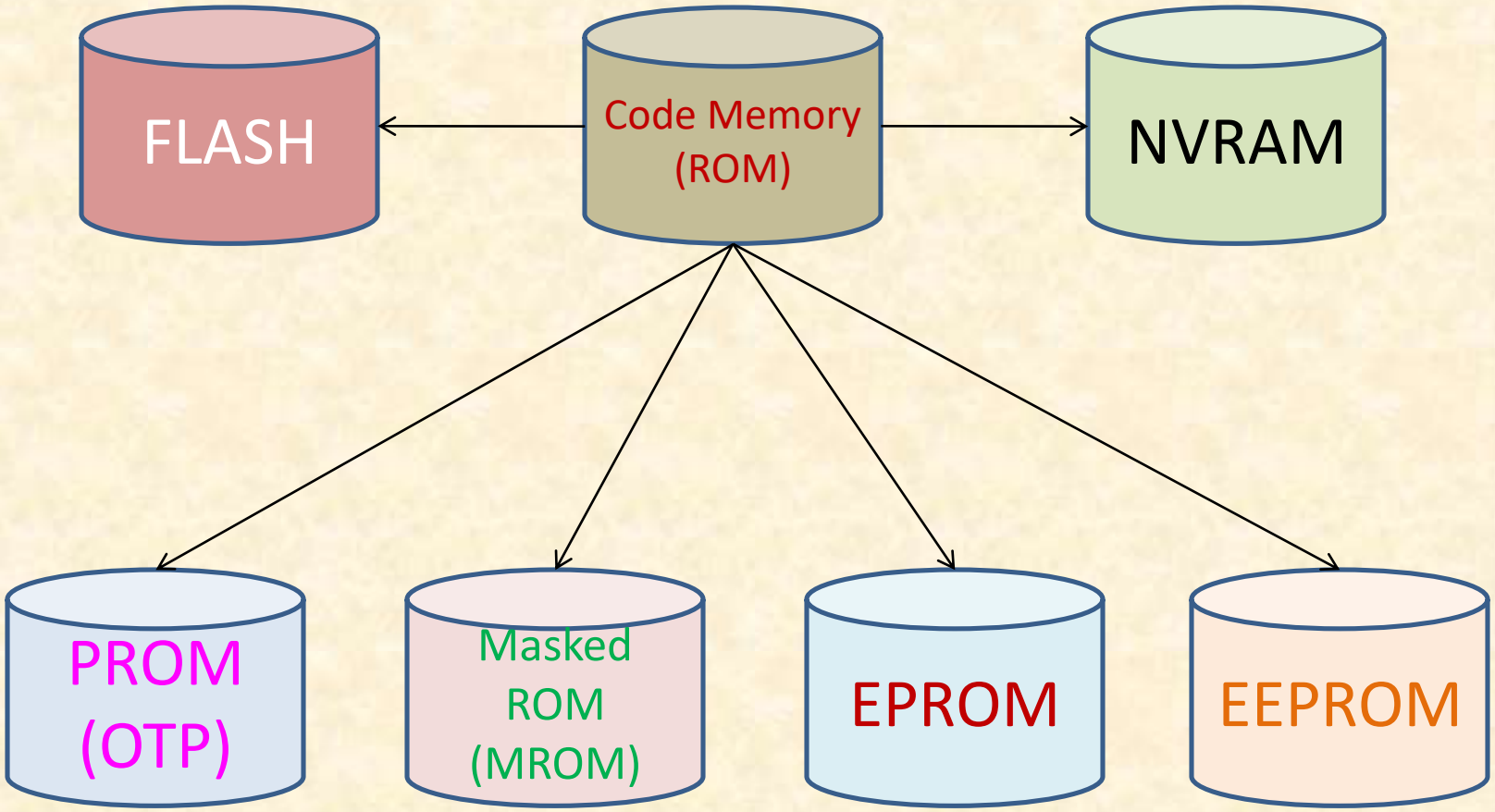
- Different types of memory used in embedded systems applications are:

2.2(a) ROM

2.2(b) RAM

2.2(a). ROM

- The program memory or code storage memory of an embedded system stores the program instructions and it can be classified into different types.
- The code memory retains its contents even after the power off. It is generally known as Non-Volatile storage memory
- It is classified into following types


FLASH
Code Memory
(ROM)
NVRAM
PROM
(OTP)
Masked
ROM
(MROM)
EPROM
EEPROM

(i) Masked ROM(MROM)

- It is a one-time Programmable device.
- It makes use of the hardwired technology for storing data
- The primary advantage of this is low cost for high volume production
- Masked ROM is a good candidate for storing the embedded firmware. For low cost embedded devices

(i)Programmable ROM(PROM)

- Unlike MROM, one time Programmable memory(OTP) or PROM is not pre-programmed by the manufacturer.
- The end-user is responsible for programming these devices
- This memory has nichrome or polysilicon wires arranged in a matrix
- These wires can be functionally viewed as fuses.
- It is programmed by a PROM programmer which selectively burns the fuses according to the bit pattern to be stored

(iii) Erasable Programmable ROM(EPROM)

- OTPs are not useful and worth for development purpose.
- During the development phase the code is subjected to continuous changes
- Erasable PROM gives the flexibility to re-program the same chip.
- EPROM contains a quartz crystal window for erasing the stored information.
- If the window is exposed to ultraviolet rays for a fixed duration, the entire memory will erased.
- time takes for 20 to 30 mins

(iv) Electrically Erasable Programmable ROM(EEPROM)

- As the name indicates, the information contained in the EEPROM memory can be altered by using electrical signals
- They can be erased and re-programmed in-circuit.
- These chips include a chip erase mode and in this mode they can be erased in a few milliseconds.

(v) FLASH

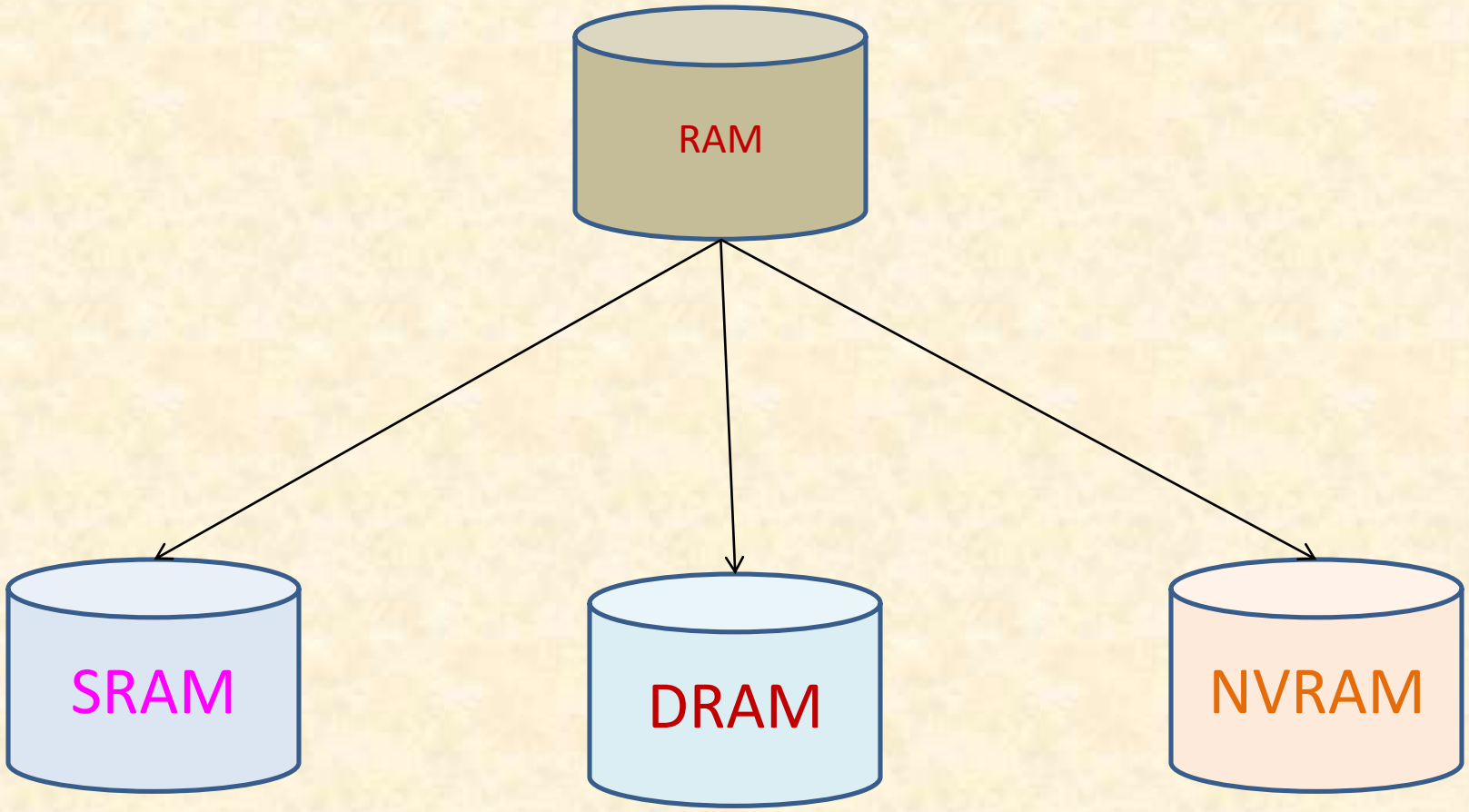
- FLASH is the latest ROM technology and is the most popular ROM technology used in today's embedded designs
- FLASH memory is a variation of EEPROM technology.
- It combines the re-programmability of EEPROM and the high capacity of standard ROMs.
- FLASH memory is organised as sectors(blocks) or pages.

(vi) NVRAM

- Non-Volatile RAM is a random access memory with battery backup.
- The memory and battery are packed together in a single package
- The life span of NVRAM is expected to be around 10 years.

2.2(b). RAM

- RAM is the data memory or working memory of the controller/processor.
- Controller/processor can read data from it and write to it
- RAM is volatile.
- SAM: Sequential Access Memory


RAM
SRAM
DRAM
NVRAM

2.2(c) Memory interfacing according to the type of interface

- The interface(Connection) of memory with the Processor/controller can be of various types.
- It May be a parallel interface or may be serial interface like I2C or it may be an SPI.
- It can also be a single wire interconnection.
- Serial interface is commonly used for data storage memory

- The memory density of a serial memory is usually expressed in terms of Kilobits

- Whereas Parallel interface memory is expressed in terms of Kilobytes.

2.3. SENSORS and ACTUATORS

SENSOR

- A sensor is a transducer device that converts energy from one form to another for any measurement or control purpose

ACTUATOR

- Actuator is a form of device(mechanical or electrical) which converts signals to corresponding Physical action(motion). Actuator as an o/p device.