CORE OF EMBEDDED SYSTEM

Embedded systems are built around a central core and the core belongs to any of the following categories:

1. General Purpose and Domain Specific Processors
   - Microprocessors
   - Microcontrollers
   - Digital Signal Processors
2. Application Specific Integrated Circuits (ASICs)
3. Programmable Logic Devices (PLDs)
4. Commercial off-the-shelf Components (COTS)

Digital Signal Processors (DSP) : Digital Signal Processors (DSPs) are powerful special purpose microprocessors which are faster than the general purpose microprocessors in signal processing applications.

*Application Specific Integrated Circuits (ASIC*s) : Application Specific Integrated Circuit (ASIC) is a microchip which integrates several functions into a single chip and there by reduces the system development cost.

Programmable Logic Devices (PLDs): Logic devices provide specific functions such as data communication, display, timing and control operations. These devices can be reconfigured to perform any number of functions. Eg: FPGA (Field Programmable Gate Arrays)

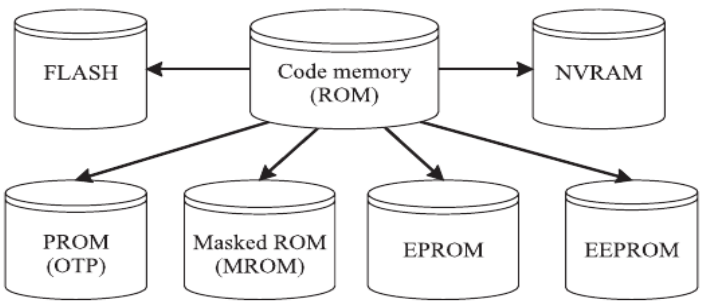
Commercial off-the-shelf Components (COTS): These are ready to use products available in the market. Its main advantage is that it is cheap and can save development time. Eg: Remote control circuit unit used in toys.

MEMORY AND ITS CLASSIFICATION

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 the controller/processor to store the control algorithm. It is called off-chip memory. Also some working memory is required for holding data temporarily during certain operations.

Program Storage Memory:

The program memory or code storage memory of an embedded system stores the program instructions in a non volatile storage (ROM) and the program memory is classified into different types as shown below.



Masked ROM : This memory is factory programmed according to the data provided by the user. They are low cost for high volume production.

PROM (Programmable Read Only Memory) : PROM is programmed by the user. These are not re-programmable (OTP – One Time Programmable)

EPROM (Erasable Programmable Read Only Memory) : It can be reprogrammed using an EPROM programmer. The erasing is done using ultraviolet rays.

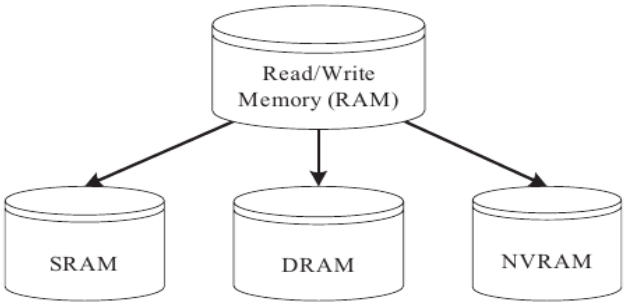
EEPROM (Electrically Erasable Programmable Read Only Memory) ; In this, reprogramming can be done using electrical signals. They can be erased and reprogrammed in-circuit.

FLASH : FLASH is the latest ROM technology. It combines the re-programmability of EEPROM and the high capacity of standard ROMs. It operate at high speed.

NVRAM (Non Volatile RAM) : It is random access memory with battery backup. It contains static RAM based memory and a small battery for providing supply to the memory in the absence of external power supply.

Data Storage Memory:

RAM is the data memory or working memory of the controller/processor. RAM is volatile and processor/controller can read or write data. RAM generally falls into three categories as shown below:



Memory shadowing

RAM access is about three times faster than ROM access. To speed up the execution, the code from ROM is copied to RAM. This method is called memory shadowing.

Memory selection for embedded systems

Three types of memory is required in an embedded system.

1. Program Memory : To hold control algorithm (program) and embedded OS
2. Data memory : To hold variables and temporary data during execution
3. Memory for holding non-volatile data : To hold configuration data

How much memory is required for these purpose is completely depend on the the type of embedded system and the applications for which it is designed. Lot of factors need to be considered when selecting the type and size of memory for embedded system as listed below:

- Identify whether the on-chip memory is sufficient or external memory is required
- If the embedded design is based on an RTOS, it requires certain amount of RAM for its execution and ROM for storing the RTOS image
- It is better to add an extra buffer size to the total estimated RAM and ROM size requirements
- Always consider the memory size and type needed for the execution of the task for which the embedded system is designed.
- Choose the memory chip with next size closer to the requirement

- Consider the maximum memory capacity supported by the processor. (For example, it is meaningless to select a 128Kb memory chip for a processor with 16 bit wide address bus, because this processor can support maximum 64Kb).
- Ensure that the word size supported by the memory chip matches with the data bus width of the processor/controller.

SENSORS AND ACTUATORS

A sensor is a transducer device that converts energy from one form to another. Sensors are connected to the input port of an embedded system. Sensors detect values (for example, temperature) and convert it into another form through signal conditioning acceptable by the processor/controller.

Actuator is a form of transducer device (mechanical or electrical) which converts signals to corresponding physical action (motion). Actuator acts as an output device.

I/O Subsystem

The I/O subsystem of the embedded system is used to interact with the external world. The interaction happens through the sensors and actuators connected to the input and output ports respectively of the embedded system. Following is a list of sensors/actuators used in embedded system.

- Light Emitting Diode (LED) : LED is an important output device for visual indication in any embedded system. It can be used as an indicator for the status of various signals or situations

- 7-Segment LED Display : It is an output device for displaying alpha numeric characters. It contains 8 light-emitting diode (LED) segments arranged in a special form.

- Optocoupler : Optocoupler is used to isolate two parts of a circuit. In electronic circuits, an optocoupler is used for suppressing interference in data communication, circuit isolation, high voltage separation. Optocouplers can be used in either input circuits or in output circuits.

- Stepper Motor : A stepper motor is an electro-mechanical device which generates discrete displacement (motion) in response to dc electrical signals. The paper feed mechanism of a printer/fax makes use of stepper motors for its functioning

- Relay : Relay is an electro-mechanical device. In embedded application, the 'Relay' unit acts as dynamic path selectors for signals and power.

- Piezo Buzzer : Piezo buzzer is a piezoelectric device for generating audio indications in embedded applications

- Push Button Switch : It is an input device. It is used to generate a momentary pulse

- Keyboard : Keyboard is an input device for user interfacing. For data entry, a matrix keyboard is interfaced with the controller. 16 keys can be used in a 4 Column x 4 Row matrix keyboard.
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- Programmable Peripheral Interface (PPI): Most of the processors/controllers provide very limited number of I/O ports. If we require more number of ports, we can use Programmable Peripheral Interface. Eg: intel 8255A