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FROM APPOSITE PREFERENCE TO SPECIFIC APPLICATION: AN OVERVIEW OF MICROCONTROLLER UNIT

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Abstract-A microcontroller is a small and inexpensive processor built for the purpose of dealing with definite odd jobs, such as displaying information, accepting information from system. Microcontrollers are chiefly used in stuff that requires a level of control to be exerted by the consumer. An embedded system can be defined as the computing engine that has computer hardware, either with software embedded in it as one of its most vital ingredient. It may be an autonomous collection or a part of a superior arrangement. This is a technical review of embedded microcontrollers and how they are used and invoked in today's devices. It is very intricate to select a particular Microcontroller for particular function. Triumph or malfunction of any development largely depends on suitable selection of the Microcontroller Unit. In this paper a brief overview of the unit is described as far as the precise selection for particular application is concerned. So many manufactures are producing microcontroller in mass quantity. Evaluation is based on products of few primary manufactures. System requirements, availability, performance, size, power dissipation, flexibility, Reliability, Maintainability, Environmental constraints, software support, correctness, safety, Cost, manufacturer's history and track records are the fundamental factors to be considered whenever a system is to be materialized using a microcontroller which is the compassion of the appliance. In this paper several factors are focused and follow up of those factors that will help us to select a particular Microcontroller for specific applicability.

1. INTRODUCTION

An embedded system is some blend of computer hardware & software, either fixed in potential or programmable which is entirely designed for a particular kind of relevance device. Embedded systems are not always split devices. Most often they are physically built-in to the devices they manage. The software written for embedded systems is often called firmware, and is stored in read-only memory or Flash memory chips rather than a disk drive. It often runs with restricted computer hardware resources: small or no keyboard, screen, and little memory. With the extension of semiconductor fabrication technology manufacturers are able to coalesce memory, input/output interfacing circuits, Timer, Serial port and Analog to Digital Converter and other peripherals into the microcontroller. Thus it is fundamentally an entire chip fabricated on a single chip.

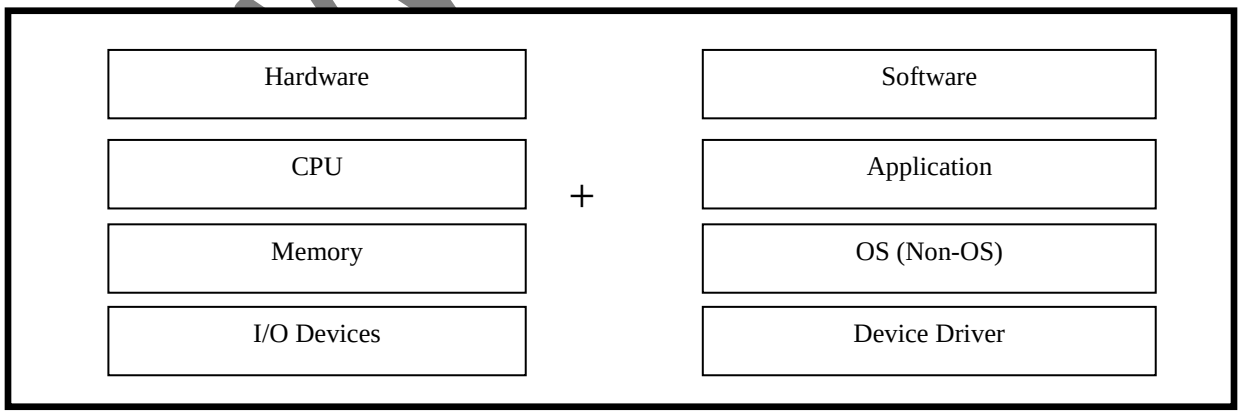

Fig. 1.1 Embedded Systems

The single chip microcontrollers are used in consumer products like washing machines, copiers, AC machines, printers etc., high speed data processing similar to video conference, real time compression and security system, image processing etc., automotive systems like electronic power steering system, antilock braking systems etc., Different industrial applications like AC and DC motor Drives, position control, motion control etc. Due to assemblage of all functional blocks on a single chip microcontroller IC, the sizes of control board and power

utilization are reduced; system dependability increased and also provides elasticity [1, 2]. The other compensation of using such microcontroller based systems are effortless troubleshooting and maintenance. All of the above mentioned fields of applications depend on the numerous factors of choosing the right microcontroller unit for explicit applications. This paper gives an overview of the critical consideration of the factors fulfilling the system conditions by reducing the total cost which includes the cost of manufacturing, warranty, research and development, after sale service, maintenance, replacement etc.

1.1 Characteristics

Embedded system are intense to a scrupulous application include processors keen to specific functions. It performs a firmly mend set of functions; increasingly high performance and real time constrained. Power, cost and reliability are often key attributes that influence design.

1.2 Architecture

Embedded systems have turn out to be an crucial part of daily life. These systems have been touching and altering modern lives like never before. The major building blocks of an embedded system are listed below:

- Microcontrollers / digital signal processors (DSP)
- Integrated chips
- Real time operating system (RTOS) - including board support package and device drivers
- Industry-specific protocols and interfaces
- Printed circuit board assembly

The following figure illustrates the architecture layers for an embedded system. The architecture of an embedded system is an abstraction of the embedded device, meaning that is a generalization of the system usually doesn't show detailed implementation information such as software source code and hardware circuit design. At the architectural level hardware and software mechanism are an embedded system are instead representation as some symphony of interacting elements. The lowermost layer comprises the printed circuit board that accommodates all the semiconductor devices, buses and related electronics. The semiconductor devices may include integrated chips, microcontrollers, field-programmable gate arrays (FPGAs) or a 'Computer on chip'. The uppermost layer is the application layer. In-between, there are additional layers which may encompass components like device drivers and communication protocols. A special variety of operating systems known as the real-time operating system (RTOS) is generally required to cater to the deadline-driven requirements of an embedded system.

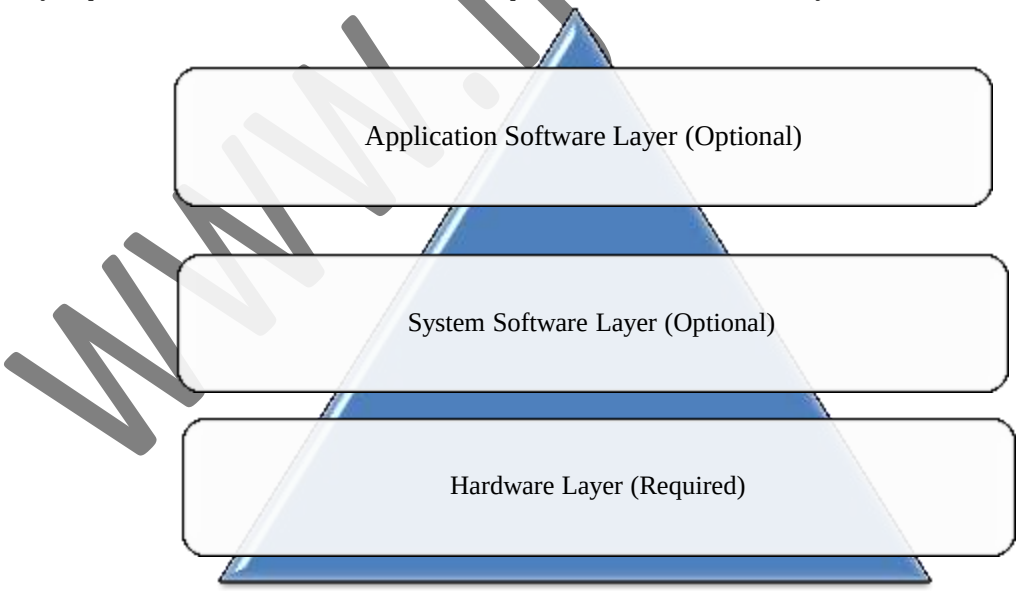

Fig. 1.2 RTOS (Real-Time Operating System)

RTOS is the intelligence of real time system. Foremost role of an operating system is to deal with resources so as to meet the demand target application. Modern real time systems are based on complementary concept of multitasking and inter task communication. Real-time embedded systems are defined as those systems in which the exactness of the system depends not only on the logical result of computation, but also on the time at which the results are

produced. If the system delivers the correct response, but after a certain time limit, it could be regarded as having failed.

2. CATEGORIZATION BASED ON ARCHITECTURE

In 1993, the foreword of EEPROM permitted microcontrollers (launch with the Microchip PIC16x840) to be electrically erased rapidly. It allows both express prototyping and In-System-Programming (ISP). The identical year, the first microcontroller using Flash memory was introduced by Atmel.

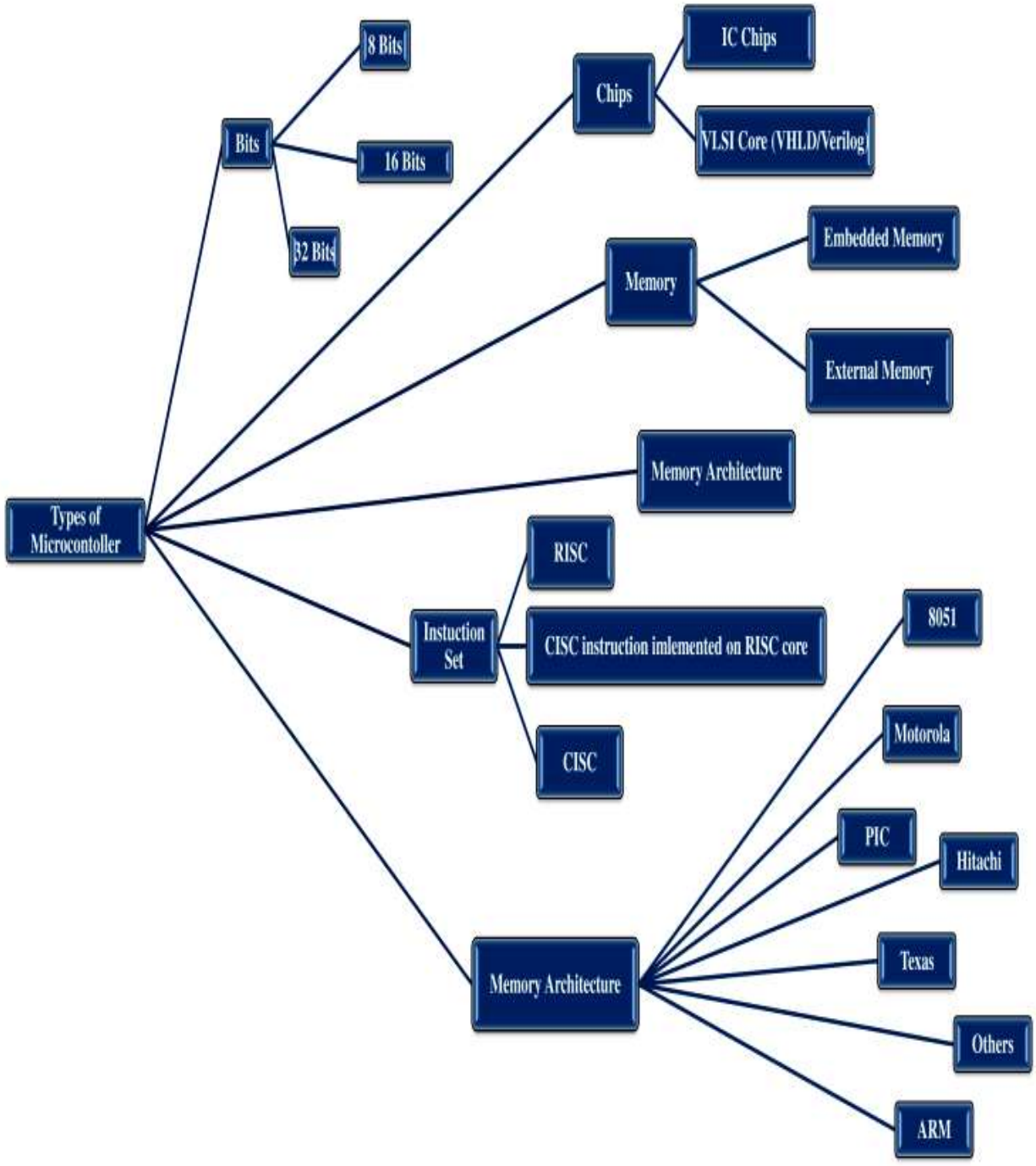

Fig. 2.1 Classification of Microcontroller

4-bit to 32-bit microcontrollers are accessible in the marketplace. Based on the number of bits it is roughly classified into four different categories i.e., 4-bit, 8-bit, 16-bit and 32-bit microcontrollers.

Table-2.1 Various Microcontrollers and Their Application

Microcontroller	Application
4-bit microcontrollers	Broadly used in electronic toys.
8-bit microcontrollers	Commonly used in different control applications such as position control, speed control and any process control system
16-bit microcontroller	Designed and developed for the utilization of high speed control application such as servo control system, robotics etc. Programming of such microcontroller can be achieved either by high level programming language or by assembly language programming. For very high speed operations in robotics, image processing, automobiles, intelligent control system and telecommunications
32- bit microcontrollers	A superior version of 16-bit microcontrollers. The 32-bit microcontrollers are built with utmost range of On-chip memories and hence are used for larger applications. The performance is very fast and cost effective.

3. COMMONLY USED MICROCONTROLLERS AND THEIR FEATURES

A microcontroller is a solitary integrated circuit, have a variety of significant features. Central Processing Unit ranges starting from 4 bit processor to 32 or 64 bit processors. It has volatile RAM for data storage, ROM, EPROM, EEPROM, Flash memory for programming as well as storage of the processing parameters. Bi-directional I/O pins allowing control and uncovering of logic state, UART, Serial communication Interfaces like I2C, Serial peripheral interface and controller area network for system interconnect, peripherals like timer, counter, PWM generator, watchdog timer, clock generator, ADC, DAC and finally in circuit programming and debugging support.

Table 3.1: MCUs and Their Features

Frequently Used Microcontroller Unit	Features
Intel 8051	It is underneath 8-bit Microcontroller family. ROM ranges from none to 8KB, RAM Size of 128 or 256 bytes (depending on the particular part number). Clock frequency is up to 12 MHz. Ultra violet light erases data and special electrical programmer writes new data. Architectures consist of four bi-directional I/O ports of 8 bits each.
Atmel AT89CXXXX	ROM used here are of Flash type and size ranges from 1KB to 8 KB to 256 bytes of RAM. Utmost clock speed is up to 20 MHz. They have 15 to 32 number of bi-directional I/O pins, 1 to 3 number of timers, and 3 to 8 numbers of Interrupts.
Dallas Semiconductor DS89C4XXX, DS5000, DS80C320, DS87520	They use both Flash type and UVROM type ROM. Size ranges from none to 64 KB. RAM ranges from 128 bytes to 256 bytes. Total 32 no. of bi-directional I/O pins form 4 different ports. 2 to 3 timers and 6 interrupts are available.
Freescale 68HC11	This is under another 8 bit microcontroller family. Either UV erasable or electrically erasable ROM is used here. RAM is in the order of none to 768 bytes of size. They run at clock speeds range up to 3 MHz. Eight 8 bit A to D converters are also embedded for monitoring analog signals.
Philips Corporation	Major manufacturer of 8051 family. The products includes A to D converters, D to A converters, extended I/O pins, OTP and Flash type ROM .
Texas Instruments ARM Stellaris LM4F	Combines the features of 16 bit and 32 bit. It includes different type of memory, including 2 KB of electrically erasable ROM, 256 KB of flash and preloaded software libraries as factory programmed ROM. It runs at clock speed up to 80 MHz. It supports not only universal serial bus 2.0 but also RS-232 data communications.
Zilog Older: Z8, Z180 Newer: eZ8, eZ80, Z16	Z8 has 8 bit Harvard architecture ROM/EPROM/OTP microcontroller with on-chip SRAM. eZ8 has better pipelined Z8 therefore 2-3 times as clock efficient as original Z8 with on-chip flash memory and SRAM. Z16 has express 8/16/32 bit CPU with condensed object code, 16 MB (4 GB possible) addressing range, flash, SRAM, peripherals on-chip
Microchip PIC16C5X/XX	This 8 bit microcontroller family is manufactured by Microchip Technology. Though lower running clock frequency saves energy but maximum clock speed is limited to 40 MHz. Architecture includes 512 bytes to 2K bytes of ROM, 25 to 73 bytes of RAM, 8 bit real time counter, programmable sleep mode and watchdog timer.

4. CRITERIA FOR CHOOSING A MICROCONTROLLER

Real-time computing deals with all difficulty in computer architecture, fault-tolerant computing and operating systems are also problems in real-time computing, with the additional complication of having to assemble real-time constraints. Real-time computer systems diverge from general-purpose systems

- They are more precise in their applications
- The consequences of their failure are more drastic
- Emphasis is placed on meeting task deadlines.

Choosing a microcontroller from a quantity of different microcontrollers is a very serious decision for the designers. Three are the vital foremost criteria for selecting them. These are

- Wide availability and reliable sources
- Meeting the requirements efficiently and cost effectiveness.
- Availability of the software development tools like compilers, assemblers and debuggers etc.

Selecting the right microcontroller for a product can be a daunting task. Not only are there a number of technological features to consider, there are also production case issues such as cost and lead-times that can cripple a project. At the launch of a project there is a great enticement to hop in and start selecting a microcontroller before the details of the system has been hashed out. This is of course an awful idea. Before any deliberation is given to the microcontroller, the hardware and software engineers should work out the high levels of the system, block diagram and flowchart them and only then is there adequate information to start building a rational decision on microcontroller selection. When that top is reached, there are 10 easy steps that can be followed to ensure that the right choice is made. The following steps should be followed during selection of the MCU.

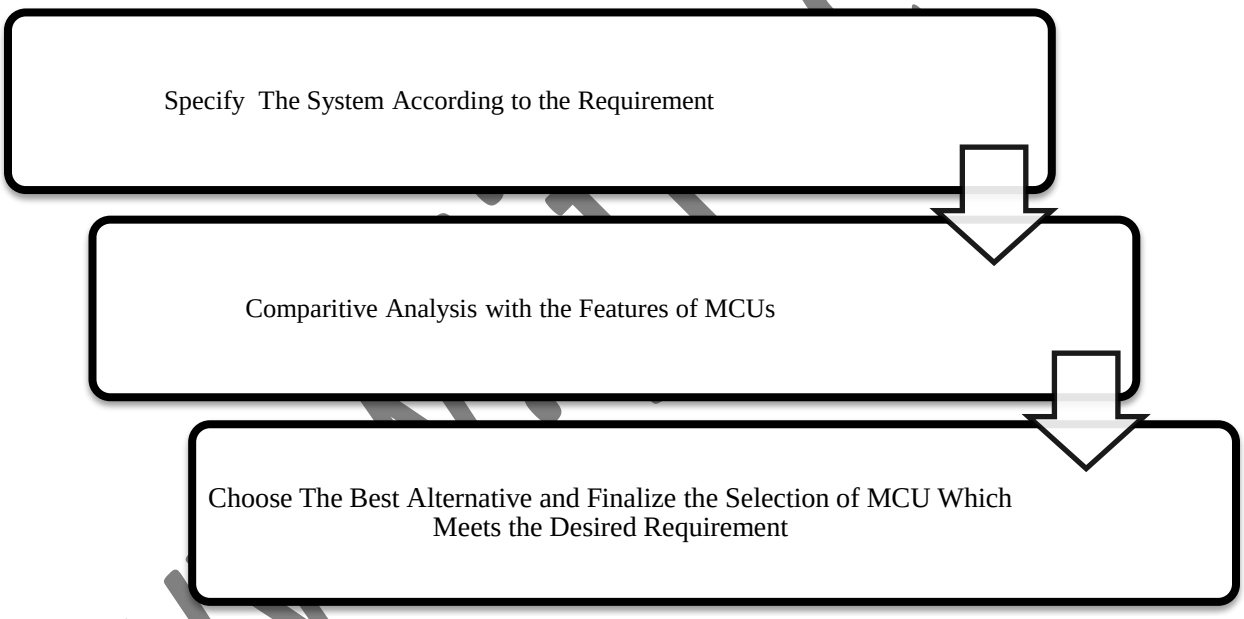

Fig. 4.1 Process Flow of Selection

The key criterions in selecting a microcontroller are given below in the order of importance.

4.1 System Prerequisite

Design should start with a void sheet of paper specifying the application requirements, if the system requires a single chip MCU or additional peripherals are to be used with it. Selection process starts with a decision of choosing either the 4-bit, 8-bit, 16-bit or 32-bit microcontroller required by the application. To expand code for 4-bit architectures is harder and handling 4-bit instructions and data widths can limit arithmetic capabilities. Most of the embedded applications are implemented using 8-bit microcontroller as the technology has been around a long time and huge number of controllers is available in the market. They are used from low cost, low speed 4-bit micro replacement to device which deliver tens of MIPS, such as Atmel's AVR series which achieves a 50 ns instruction cycle time when clocked from a 20 MHz crystal. If the application needs more processing power the choice is most likely to be 16-bit or 32-bit MCU. Vendors offer 32-bit performance cost effectively. 32-bit devices come at virtually no cost to the user. The on chip peripherals available exhibit heavy influence on component selection. Check the accessibility of Timers, Serial interfaces, ROM, RAM, A/D converter, D/A converter adequate number of I/O ports. Too many I/O ports lead to bear excessive cost but few cannot do the job [3, 4].

4.2 Memory Architecture

Most important factor while designing any microcontroller based system. Three different types of memory play an important role in the selection process are

- program memory i.e. Flash, OTP, ROM and ROM less components
- Data memory i.e. on-chip SRAM or external SDRAM
- Non volatile Memory i.e. EEPROM or Flash.

Whether the memory is on-chip or off-chip and how much the size is required may be a key factor defines cost of building the system and speed of operation. For an example Atmel AVR family include Flash memory of 1KB to 128KB, on chip SRAM for data storage and for the storage of configuration information and serial numbers a few bytes of EEPROM are reserved. These fair features make the AVR family trendier in different applications. Flash gives the elasticity to make code changes and provides capability to use In-System-Programmed. Atmel 89C51 and Mega AVR families have the segmented Flash blocks which allows reprogram one segment under control of another segment, without removing the power [4]. Lastly it is best to choose a device from a family which provides ample or more memory space than the expectation of need.

4.3 Check the Part Availability

Before going to apply the system, the accessibility of the device should be checked. The criteria in choosing microcontroller is its ready availability in needed quantities both now and future. If adequate quantities are available with vivid future then no need to be alarmed about the failure of the project.

4.4 Size

If IC of 15 I/O pins is required to develop the system there is no need to use 40 pin IC with 32 I/O pins. In this way the size of the IC can be concentrated and thus substantial space requisite to implement the system is also reduced. So, physical size of IC may well be critical factor for specific applications.

4.5 Compatibility

The function of a system can be changed or upgraded by changing the software or replacing one IC with another one without incurring heavy additional cost. The latest one will be pin compatible as well as utility compatible.

4.6 Functionality Testing

To check the function of the implemented system correctly the function of the MCU should be checked within the test circuit premeditated earlier before going to enlarge the overall system.

4.7 Power Constraints

More power means more heat dissipation which leads to wastage of energy. Power consumed by the system determines the lifetime of the battery. Due to reduction in size of the devices the size of the machinery are reduced and their placement within the design is very compressed. This phenomenon makes the devices to be responsive to the heat dissipated from the MCU and the other peripherals connected with it. It is the duty of an engineer to look first at the power required at the clock speed necessary to run the application. ROM based devices tolerate very low operating voltages (around 0.9v). In case of Atmel AVR devices Flash based microcontroller can be operated at the voltages down to 1.8V. Most microcontrollers have the features of power down, idle & sleep modes and reflection needs to be given to maximize the use of intellectual power managing systems to reduce power expenditure [6].

4.8 Manufacturer's Track Record

Manufacturers should endorse the stability, good performance, better throughput, Reliability; better Serviceability, software support, correctness, wide and timely availability of their products. For an illustration artefact of Intel, Freescale, Zilog, and Microchip Technology are stable, mature and single sourced. The points like design challenges, on time delivery, performance, years in business and year of transaction, financial report should be followed as the pathway record of the manufacturers. They must provide the datasheet or user guide which consists of characteristics, functionality, sample test circuit, electrical characteristics and dimension etc. The documentation of maintenance of the development system, the range of services and its associated software must be available for the common user [3].

4.9 Manufacturer's Support

During the step by step functioning of the system if the design engineer faces any kind of crisis he/she may communicate with the marketing/sales, field application engineers. The manufacturers should have some amenities

resembling a help line, toll free number, fax number, after-sales support, sufficient knowledgeable and helpful proficiency support personnel who will give a prompt reply or they will follow through in a regular manner when they promise to do something.

4.10 Availability of Development Support

Here the key consideration includes Assembler, Debugger, a code efficient C compiler, emulator, technical support. Trend towards programming in high level language like C is increasing day by day. This language allows using of some portability of code and libraries. This provides more practical consideration using different microcontroller family. Choosing the appropriate Hardware and software enlargement tools is also essential while selecting MCU. An integrated development environment (IDE) facilitates the development efforts by providing the project management tools. IDE enables to create source files and their organization in to a project, formation of database for many devices. An example of IDE is Keil uVision 2 which compiles to point out and correct the errors, assembles and links the device datasheet, user guides and development tool manuals. Another good example is MPLAB for PIC and dsPIC microcontrollers from Microchip Technology. This is mainly used for development of embedded systems [5].

4.11 Cost

Most momentous factor for assortment criterion. If the system is to be implemented within the limit of the funds calculated earlier the expenditure of each and every element (selected MCU along with supporting ICs) used to build the system should be minimized tactfully to fulfill the pitch. On chip features will trade with supply and assembly cost of using extra underneath external components. They can also cut development time and effort by providing a ready incorporated solution [4]. Design of special hardware requires non recurring engineering cost and cost for manufacturing the unit. Integration of some peripherals like 10/100 base T Ethernet MACs, CAN bus interfaces, USB, RF transmitter and graphics driver cuts the system cost in some great degree. For high volume applications most users prefer ROM based devices due to their lower cost and code security.

CONCLUSION

The choice of devices available today is enormous. Therefore we must know what type of Microcontroller suitable for particular applications. Selecting the proper microcontroller unit (MCU) for specific application is one of the critical decisions which control the success or failure of your project. There are numerous criteria to consider when choosing an MCU and this application note will enumerate most of them. It presents an outline of the contemplation process guiding this decision. The main goal is to select the least expensive MCU that minimizes the overall cost of the system while still fulfilling the system specification, for example, performance, reliability, environmental, etc. The overall cost of the system includes everything, such as engineering research and development (R&D), mechanized (parts and labor), warranty repairs, updates, field service, upward compatibility, ease of use, etc. This paper presents various criteria to select MCU and the application note will enumerate most of them. The decision is not so easy and it will become critical as the technology is upgrading rapidly. Few guidelines of choosing the right one have been focused here. Anyone can include other grading scale and their personal decision. So the selection process is not restricted to the views and thoughts highlighted in this paper.

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