A Study on Applications of Consumer Electronics and Challenges Faced by usage of Embedded Systems

Ravishanker M[1]
[1]Department of Electronics & Communication Engineering
Global Academy of Technology
Bengaluru, India

Ujwal Kiran T[1]
[1]Department of Electronics & Communication Engineering
Global Academy of Technology
Bengaluru, India

Vaishnavi M[1]
[1]Department of Electronics & Communication Engineering
Global Academy of Technology
Bengaluru, India

Prof. Dr. N Guruprasad[2]
[2]Professor-Department of Computer Science & Engineering
Global Academy of Technology
Bengaluru, India

***Abstract* — This paper explains the introduction, generation and evolution of embedded systems. The embedded technology's prominence in the sector of consumer electronics and improvement in the field of consumer electronics with advancements in embedded technology. Usage of embedded systems in the washing machine, with regards to harmonious working of sensors, actuators and the micro-controller unit, with special reference to the hardware and design specifications and an algorithm for foolproof system operations. Embedded systems offer a few challenges and difficulties that are inherent to this technology and require special attention by developers and Original Equipment Manufacturers (OEMs).**

Keywords— Consumer Electronics, Embedded Systems, MCU, Sensors, Washing Machine

I. INTRODUCTION

The word embedded refers to a circuit built-in to the system and the word system specifies the way in which a task has to be performed. Generally, these systems operate on real-time computing and are called real-time operating systems (RTOS). An embedded system is unique in character and behavior with specialized hardware and software.

As general-purpose computers could not perform application-specific tasks, embedded systems were created, which are tailored to carry out a distinct task. The idea of the first embedded systems can be backdated to the early 1960s. In 1961, the first ICs were used on the Apollo guidance computing system designed by Dr Charles Stark Draper. This system was designed to collect data and perform mission-critical calculations. In the year 1965, the First, mass-produced embedded systems were designed and manufactured by Autonetics. In 1968, to control fuel injection systems on the Volkswagen 1600, the first embedded system for automobiles was designed. In 1971, Intel manufactured the first commercially available embedded system or IC called The Intel 4004.

Based on generation embedded systems are classified as:

1. First-generation
2. Second-generation
3. Third-generation
4. Fourth-generation

- First-generation embedded systems were built around 8-bit microprocessors like 8085 and 4-bit microcontrollers.
- Second-generationembedded systems were built around a 16-bit microprocessor 8 or 16-bit micro-controller.
- Third-generation embedded systems were built around a high-performance 16bit or 32bit microprocessor or microcontroller with add-ons such as Digital Signal Processing [DSP] and Application Specific Integrated Circuits [ASIC].
- Fourth-generationembedded systems were built around System on Chips [SoCs], multicore reconfigurable processors.

Based on functional operations embedded systems are classified as:

1. Standalone embedded systems
2. Mobile embedded systems
3. Network embedded systems
4. Real-time embedded systems

- Standalone embedded systems do not belong to or rely on a host system, they operate as a single unit such as calculators, MP3 players.
- Mobile embedded systems are designed to be portable and compact and also to provide ease of use such as a camera.
- Network embedded systems are used to offer network systems, such as home security systems where cameras and sensors are connected to the same network.
- Real-time embedded systems operate on a time basis. The output is expected in a pre-defined

period. They are used in the healthcare industry, military, traffic controllers and automatic driving systems.

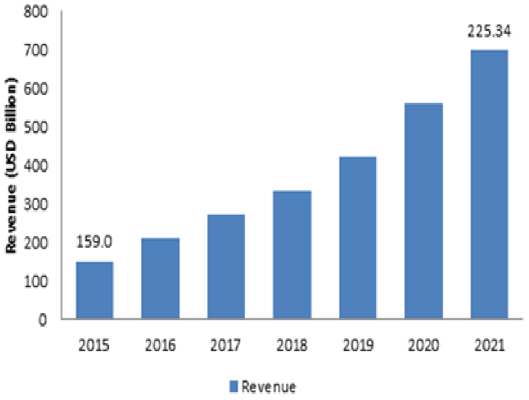

Fig.1. Embedded System's market size over the years

Embedded systems are a rapidly growing sector in the past six years, the market growth of embedded systems has grossed over USD100 billion currently standing at USD225.34 billion industry. The market shows promising growth for another six to seven years.

OBJECTIVES OF THE STUDY

- To elucidate the use of embedded systems in consumer electronics
- To establish the use of embedded systems in washing machines
- To find out the challenges confronted during the use of embedded systems in electronic software and hardware.

II. TO ELUCIDATE THE USE OF EMBEDDED SYSTEMS IN CONSUMER ELECTRONICS

Consumer electronics, generally known as Home electronics are electronic devices meant for everyday usage mostly in private houses.

Consumer electronics take in the devices which are mostly used for purposes like entertainment, recreation and communication.

Embedded technology is playing an important role in consumer electronics.

Systems ranging from microwaves, washing machines, DVD players, Television, mobiles to most medical devices like BP meters, sugar-level meters, MRI scanners, use embedded systems.

To sum it up, any device that performs a specific task requires its own software and OS.

Using embedded, individual systems can be created for ultra-specific applications.

Technology advancement changes the world around us as electronic devices talk to each other without human interference.

The Consumer Electronics industry encourages an abundance of opportunities for Integrators, original manufacturers and the embedded vision suppliers.

A. Embedding sensors

The biggest conference stories for this year has been the "sensorization" not just of consumer electronic devices like mobiles, smartphones, etc., but also about the wirelessly connected embedded devices in the opinion of a chief economist and a senior director of research at CEA, Shawn Dubravac.

The cost of sensors and MCUs have dropped, therefore causing the developers of touch and gesture-enabled devices like smartphones, smart TV's to waste more funds and time on such resources by installing more than one sensor in all the electronic embedded devices in order to improve the quality and increase the capacity.

But, beyond the use of embedding sensors in Consumer electronic devices, MCU-powered embedded sensors gather the details from various wirelessly connected devices and store the data in the cloud computing services.

Home security systems, home appliances, printers, and many more, are some of the ways how embedded systems are making their way through the various aspects of consumer electronic devices

Simple embedded systems provide a plethora of features. It collects inputs from the users and controls that particular appliance according to user description.

Some of the simple embedded systems are refrigerators, microwave ovens, gaming consoles etc.

They use sensors to collect information regarding the function of the appliance and also modify the settings correspondingly.

Some of the consumer electronic devices like home security systems use peripheral sensors with the embedded systems to make sure a house or a workplace is kept safe, which when activated alerts the users by initiating an alarm in case of an emergency.

The world's leading revolutionary semiconductor solution, Samsung Electronics, Co., Ltd., on June 29, 2009, announced the latest in its popular ARM11 series application processor (Fig 1), the S5P6440 which is based on ARM1176 CPU core which can run at the clock speed of 667MHz or 533MHz, designed with the help of Samsung's advanced 45nm low power CMOS process technology keeping in mind the improvements in CPU performance at low power and offer a vivid graphical interface for a better user experience.

They offer low-cost solutions and ensure performance at higher levels.

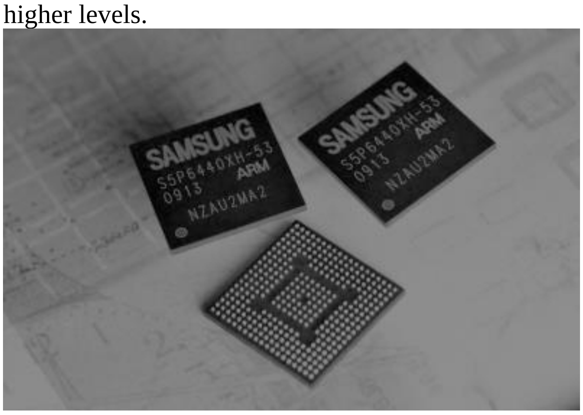

Fig. 1. ARM11 Processor

III. TO ESTABLISH THE USE OF EMBEDDED SYSTEMS IN WASHING MACHINES

A washing machine (Fig 2) is a large home appliance that removes stains and dirt from clothes by agitating them, using detergent and water.

Depending on the position of loading the clothes they are of two types,

1. Top loading washing machine
2. Front loading washing machine

Depending on the automatic feature they are of two types,

1. Semi-automatic washing machine
2. Fully automatic washing machine

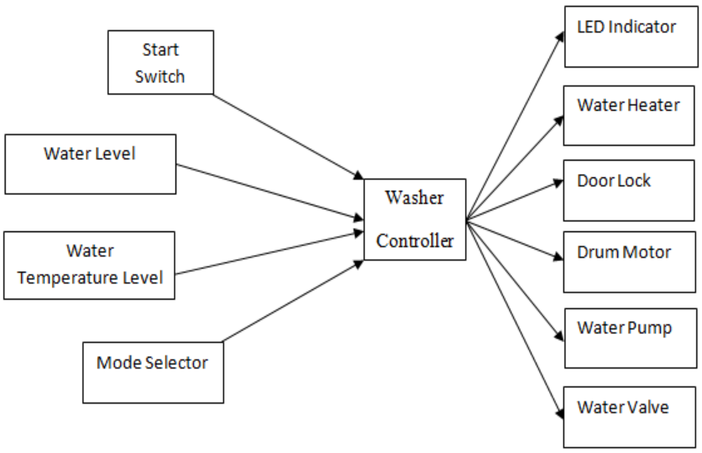

Fig. 2. Basic block diagram of washing machine

- Start Switch- With the start switch ON the washing machine starts operating.
- Mode selector- This will allow the user to select different washing modes based on the fabric of the clothes.
- Water level- The user will provide the level of water to be filled in the drum.
- Water temperature level- The user will provide the temperature of the water at the inlet.

Initially, all of the inputs had to be given manually by the user. With the current advancements in technology and using algorithms, these processes are done automatically.

A. Design Specifications of a typical washing machine

Although washing machines (Fig 3) are large electrical appliances, they need regular 3-prong 120V outlets for optimal operation. Voltage rating changes based on the laundry load, a stabilizer is used to control the voltage fluctuations.

In the event of power failure, the washing machine should automatically resume its cycle right from the point of loss of power. The mode will be selected by a keypad based on which the operation will be performed. According to the selected mode, it should sense the quality of the cloth, water requirement, water temperature, detergent requirement, laundry load, wash cycle time and perform operations. When the door is open, the system should disable all the operations. When the door is accidentally opened in between wash operations, then the system should halt the wash cycle in the least possible time.

B. Software Design

Several programming languages are used such as Python, C, C++ and Java. The popular trend is to use high-level object-oriented languages such as Java. Based on the hardware design and specifications a pseudo code or algorithm for the software can be designed. Upon detecting the keypress it initializes the operations and invokes a function written in the program code which in turn invokes many other functions. Mode status flags will be set and will be uploaded to internal EEPROM. Certain parameters will be loaded to the RAM from external EEPROM and further operations will be executed.

C. Suitable selection of microcontroller

When choosing a microcontroller, there are several choices.

Some of the microcontrollers used are the 32-bit Arm Cortex-M0+, M3 and M4 microcontrollers. The most utilized microcontroller is the AT89S51 microcontroller.

D. Hardware and Schematic Representation

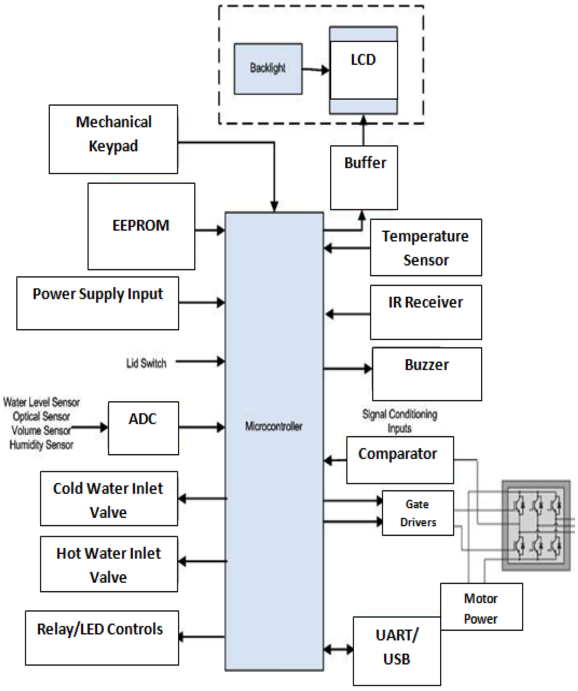

Fig. 3. Washing Machine block diagram using MCU

As soon as the start button is pressed, the input will move from the front panel to the micro-controller and the MCU initiates the three-phase brushless DC (BLDC) motor. As suggested by the front panel, the speed of the motor varies.

The MCU with the help of a real-time clock (RTC) displays accurate time information. The clock is helpful in adding delays or implementing sleep mode. The MCU utilizes an internal or external serial EEPROM [I2C/SPI bus] to store data such as washing programs, child lock protocols and favorite setups. Measurement of temperature of the water is done using an onboard thermistor, or a thermocouple-based temperature sensing device. The inputs from the sensors are analogue (water level sensor, laundry load sensor, detergent sensor), MCU uses an external ADC and amplifiers for processing the data. To drive and control the 3-phase BLDC, it uses gate-driver circuits, external signal conditioners, and comparators. External buffer driver circuitry is used to drive 7-segment LEDs or LCDs or graphical displays. Typically the display with a backlight is used for showing selected mode, the temperature of the water, time remaining for completion of the wash and error/warning messages. A buzzer is interfaced to generate different frequencies based on the MCUs instructions.

Inputs to the MCU can be given remotely through an IR receiver attached to it which operates at 38 kHz. MCU will automatically shut down after the program is successfully executed to save power.

D. A summary of required system operation

1. User selects a wash program.
2. The start switch is turned on.
3. The door lock is engaged in the case of front load.
4. The water valve is opened to fill the drum with water.
5. The detergent will be added to the drum through the detergent hatch.
6. Based on the program the water level is sensed and the water valve is closed.
7. In case of the requirement of warm water, the heater coil is switched on.
8. After reaching the required temperature the heater is turned off.
9. After all the requirements are met, the motor turns on, undergoes a series of rotations at varying speeds to wash the clothes thoroughly.
10. After the completion of the cycle, the motor is turned off.
11. The wastewater will be drained out of the drum using a pump.
12. The pump is turned off after draining.
13. The door lock will be released.

To specify the step of the operation of the wash cycle, LEDs are used.

IV. TO FIND OUT THE CHALLENGES CONFRONTED DURING THE USE OF EMBEDDED SYSTEMS IN ELECTRONIC SOFTWARE AND HARDWARE

Embedded systems are everywhere around us. Generally, these systems are always part of a bigger system.
Embedded systems although a venture of technology decades ago, there are a few problems that plague it to date.

A few limitations of embedded systems are:

A. Safety and security

Consumers are concerned regarding the safety of their electronic devices. A survey by the TÜV SÜD safety gauge study shows that 77% of consumers who buy electronics say product safety and security is either very important or quite important. Embedded systems have actuators that will control the physical environment. Compared to general computers, embedded systems have smaller components, and are created to perform a particular task and have an OS designed specifically for a particular application. Standard security used for general computers cannot be used for embedded systems. Hence, any security breaches can cause catastrophic damage not only to the system but to its environment as well. Providing security to the individual systems has to be done by the OEMs which comes at a hefty cost.
The race to add more features and functionalities to the system results in neglect of safety and security. Initially, the embedded systems were built with the assumption that the systems will never be under security threat. Currently, these systems are spread to every corner of the globe, hence providing security is becoming a major criterion. OEMs use only a handful of tools to improve safety in their product which can be insignificant.
Embedded systems are mass-produced, hence if a hacker is able to carry out a successful attack on one of these systems, they can be replicated on all the systems of that generation.
Technological advancements are at astonishing rates and in general, embedded systems are built to last for decades. When security is being implemented, OEMs have to make sure the security protocols will not become obsolete in a few decades.

B. Difficult to upgrade

Embedded systems are designed to last for decades is an established fact. When designing the hardware and software, the life cycle of the system has to be a parameter. Outdated embedded systems are visible ubiquitously, ranging from ATMs to medical devices.
Practically, most of the devices will not get any software or firmware updates post-production. Since these devices barely get any software updates, over time the system's ability to work becomes exponentially difficult as it has to clear system glitches, bugs in the system, and interact with newer communication protocols. In several cases, the production of required hardware parts will be stopped by the manufacturer, leading to scarcity of spare parts, essentially driving the device to be inoperable. As Klein

states "Will the necessary ports or connectors still be available in two to 10 years in order to get data off the non-upgradeable devices?"
The devices won't get upgraded with software, the support for device hardware is halted, fundamentally these are dead-end devices.

C. Design Limitations

The embedded devices are required to be connected to heterogeneous devices and adapt to different networking architectures. Due to this, embedded system developers face problems in terms of flexibility during the development of embedded systems such as:

- Smooth integration of network services.
- Ease of connection among external devices
- Integrating and packing of small size chips with low power consumption and weight.

Presently a limitation in the spotlight is the power dissipation of hardware components for getting the best performance out of devices operating in real-time. The main challenge is how to construct a chip with an increasing number of transistors and have a relatively low power-consumption. As the transistor density increases the power dissipated from the chips also increases, hence the overall power density of the System-On-Chip increases. Designers should also increase the operating frequency of the system to improve performance which in turn will consume more power. Thus the designers are required to improve upon the previous design or create a new layout, which requires immense investments and R&D between each generation of chips. Therefore, power consumption has to be reduced by utilizing efficient system architecture. After designing a new efficient design, it has to be verified and tested. Verification and testing have to be done to ensure all the functions are compatible and parameters perform as desired and match the requirement.

V. FINDINGS AND SUGGESTIONS

Rapid growth of embedded systems beginning in the 1980s, due to technological advancements in memory and input/output devices. In the late 1990s, embedded products based on Linux became popular. Present-day most of the embedded systems work on Linux OS. To construct a chip with an increasing number of transistors and have a relatively low power-consumption is difficult. As the transistor density increases the power dissipated from the chips also increase, the overall power density of the System-On-Chip increases. Therefore, power consumption has to be reduced by utilizing efficient system architecture. After designing a new efficient design, it has to be verified and tested. Verification and testing have to be done to ensure all the functions are compatible and parameters perform as desired and match the requirement. MCU-powered embedded sensors leave the door open for a whole new range of consumer electronic devices.

VI. CONCLUSION

To conclude embedded systems were created to carry out a distinct task as general-purpose computers cannot perform application-specific tasks. Washing machines are getting updated constantly. Growth, development and present position are being highlighted in embedded system. From the availability of secondary data on internet we found that the source of data is authentic and displays the real progress in application and use of embedded systems.

REFERENCES

[1] Shibu KV, **"Introduction to Embedded Systems"**, TataMcGrawHill, 2009.
[2] https://www.brighthubengineering.com/consumer-appliances-electronics/38358-types-of-washing-machines/
[3] https://www.embedded.com/the-role-of-mcus-and-psocs-in-making-home-appliances-smarter/
[4] https://www.idc-online.com/technical_references/pdfs/electronic_engineering/Embedded_System_PIC18F_Series_Microcontroller.pdf
[5] https://www.ariel.in/en-in/washing-machine-101/your-guide-to-washing-machines/how-they-work
[6] https://www.geeksforgeeks.org/advantages-and-disadvantages-of-embedded-system/
[7] https://www.itrelease.com/2016/12/advantages-disadvantages-embedded-operating-system/
[8] https://www.infopulse.com/blog/challenges-and-issues-of-embedded-software-development/
[9] http://triassicsolutions.com/blog/security-requirements-for-embedded-systems/
[10] https://www.infopulse.com/blog/challenges-and-issues-of-embedded-software-development/
[11] https://www.tuv-sud.cn/uploads/images/1394418099273315280793/tuv-sud-the-importance-of-consumer-safety.pdf
[12] https://archive.eetindia.co.in/www.eetindia.co.in/ART_8800688780_1800013_TA_0ebfb520.HTM
[13] https://en.wikipedia.org/wiki/Consumer_electronics
[14] https://www.researchgate.net/publication/224097218_Optimizing_the_Startup_Time_of_Embedded_Systems_A_Case_Study_of_Digital_TV
[15] https://www.totalphase.com/blog/2019/04/impact-everyday-life-how-do-embedded-systems-work/