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Microcontroller Selection for Embedded Systems

Introduction

A key step in the product design process is the selection of an appropriate microcontroller for the specific embedded application at hand. This paper reviews the types of microcontrollers currently available for a variety of embedded applications ranging from electric toothbrushes and microwaves to cell phones and live-saving pacemaker equipment.

Underlying Technology

Microcontrollers (MCUs) are integrated circuits that contain all of the components necessary to perform computing operations on a single chip. Common to all microcontrollers is an internal microprocessor, on-board memory, and a collection of application specific peripherals. These peripherals may include, but may not be limited to, ports, clocks, timers, UART/USART, ADCs, DACs, LCD Drivers, and many others [1]. Program code is stored in nonvolatile memory and executed by an internal microprocessor in conjunction with RAM-based volatile memory. Microcontrollers interact with the physical world by communicating with onboard peripherals that are electrically connected to the pins of the microprocessor.

Implementation of the Technology

MCUs are generally integrated into embedded applications via a process that involves building an early prototype on a development board equipped with an MCU and additional external modules that are pre-connected to the MCU for convenient testing and operation. Software is written in a manufacturer specific Integrated Development Environment, such as Code Composer Studio for Texas Instruments MCUs, and transferred via USB cable to the development board for execution and debugging. Since most development boards are too large for production devices, once early prototyping of the embedded application is complete, a compact PCB layout containing the MCU chip and any additional mission critical hardware modules is generated via CAD software.

Current State-of-the-Art and Commercial Products

In an attempt to keep production costs low, embedded systems engineers must select microcontrollers that possess only the minimum number of features required for a specific application. As a result, MCU manufacturers offer a variety of microcontroller families, each targeting a specific niche of related applications. For example Texas Instruments offers the following microcontroller

families (ordered by ascending price and functional capability): Ultra-Low-Power, Low Power & Performance, Security & Communications, Real-time Control, and Safety.

The Ultra-Low-Power family includes the MSP430 subfamily which has become one of the most popular MCUs for applications where the majority of the device life is spent in standby, requiring only intermittent computation [2]. An MSP430 chip includes 64 programmable pins and a variable system clock speed enabling over 90% reduction in energy usage when the MCU is asleep [3]. By contrast, the Real-time Control family includes the TMS320F28069 chip which contains 100 pins, a maximum clock speed of 90 MHz, and a variety of additional onboard peripherals such as an ADC, programmable timers, hardware interrupts and compatibility with separate Texas Instruments addons such as PWM modules and motor drivers [4]. Consequently, the C2000 family has become one of the most popular choices for motion-specific feedback control applications [5].

A recent hardware movement known as the "Internet of Everything," has led to a spike in demand for microcontrollers that can connect to the internet. Although it is possible to add internet connectivity to almost any MCU, the process is often difficult and time consuming. Spark Inc, a startup launched in 2013, aims to make internet integration simple with the release of its Spark Core, an MCU with a built-in wifi-shield that performs internet communication via a REST API to accomplish data retrieval tasks and to deliver over-the-air updates to MCU firmware [6].

Conclusion

When it comes to selecting a microcontroller for a specific application, a variety of choices exist. In order to minimize production costs, it is important to define the functional requirements of the embedded application early in the design process and to perform a comprehensive review of several microcontroller datasheets to ensure that the MCU selected contains only the minimum number of features required to meet the performance criteria.

References

[1] M. Mayank. (2011, Jun. 5). *What Is a Microcontroller? And How Does It Differ From a Microprocessor?* [Online]. Available: http://maxembedded.com/2011/06/05/mcu-vs-mpu

[2] S. Evanczuk. (2013, Aug. 20). *The Most Popular MCUs Ever* [Online]. Available: http://edn.com/electronics-blogs/systems-interface/4419922/10/Slideshow--The-most-popular-MCUs-ever

[3] Texas Instruments, "MSP430F15x, MSP430F16x, MSP430F161x Mixed Signal Microcontroller," MSP430 datasheet, Oct. 2002 [Revised Mar. 2011].

[4] Texas Instruments Technical Staff, *TMS320x2806x Piccolo Technical Reference Manual*, Texas Instruments, Jan. 2011 [Revised Mar. 2014].

[5] D. Taylor. ECE 4550. Class Lecture, Topic: "Microcontrollers for Feedback Control Applications." School of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA, May 15, 2014.

[6] Spark Labs, Inc. (2014, May 27). *Build Internet-connected Hardware* [Online]. Available: http://spark.io