Microcontrollers for Wearable Devices

Introduction

The microcontroller plays a significant role in an embedded system design. This review examines several major design criteria of microcontrollers for wearable devices, one major type of embedded system, investigates into the relevant MCU products that are currently available on the market and covers the implementation of microcontroller into the system of wearable device.

Design Criteria (underlying technology specified)

Power Consumption

Battery powered and turned on most of the time due to their monitoring duty, wearable devices require their components, including the microcontrollers, to operate at ultra-low power level [1]. As will be introduced in the below sections, low power wireless technology such as ANT and BLE, and the performance/energy-optimized ARM architecture, are the few examples where MCU is able to save power.

Wireless Connectivity

The options for wireless communication protocols on the MCUs include: WIFI, ANT+, and BLE (Bluetooth Low Energy).

WIFI merits consideration when high data load is to be transferred with little lag. Its drawback lies in its relatively higher power consumption rate, which may require daily charging of the batteries.

ANT+ is an open access protocol that has been developed for personal area networks for the linking of devices. It is oriented towards data transfer and collection from sensors and integration of remote control systems [2]. However, its usage is limited due to its low inclusion on consumer electronics [3] (tablets, PCs, smartphones, etc.).

BLE is a low power protocol aimed for communication between mobile devices. In comparison with ANT+, BLE has a lower peak current draw and higher data transfer efficiency [4]. As of the moment, BLE has already adopted several health sensing services in its standards, including heart rate, blood pressure, and thermometer profiles [5]. The BLE can also host GATT (Generic Attribute) services for data transfer between the wearable device and consumer electronics. BLE specification includes EDR (Enhanced Data Rate) for faster data rates used for applications such as Real Time Wireless Audio Transmission [6].

Size

MCUs need to be downsized due to the limited physical space available for a wearable device. This is achieved through technologies such as SoC(System-on-Chip) and CSP (Chip Scale Packaging). For example, Cypress offers PSoC (Programmable System-on-Chip) devices in multiple packaging options including WLCSP (Wafer Level Chip Scale Packaging) [3].

Microcontroller Products (categorization by CPU)

ARM Cortex-M series

The ARM Cortex-M series, a group of RISC (Reduced Instruction Set Computing) ARM processors licensed by ARM Holdings, is a popular option of processors in MCUs in today's wearable device market. Cortex ARM processors support 32-bit data transfers, which is the status quo for wearable device's operating system [7]. The featured microcontrollers of this series include [8]:

Cortex-M0+: It features the highest energy efficiency of the M family, achieving a power consumption below 4μW/MHz, while reaching a performance efficiency of 2.46 CoreMark/MHz. The Kinetis KW30Z microcontroller by NXP, for instance, makes use of this M0+ Core, with 20kB RAM and BLE integrated, cost at 2.06/100u.

Cortex-M23: It is the enhancement version of the Cortex-M0+ [9], consuming the lowest power among all ARM MCUs and featuring the ARM TrustZone technology (an IP security measurement). Its performance is 2.50 CoreMark/MHz and 0.98 DMIPS/MHz.

Cortex-M0: Despite slightly humbler performance, M0 is the smallest footprint Arm processor with a total floorplan area of $0.007mm^2$ in a 40nm technology process. M0 also costs the least and is the most widely used in the Cortex M family. The Cypress Semiconductor PSoC 4 BLE (with BLE protocol built-in, 32kB/16kB RAM, at the cost of 4.418$/1ku) and Nordic Semiconductor nRF51822 (with ANT+ protocol built-in and 32kB/16kB RAM, at the cost of $2.31/1ku) are the two of the many MCU products that utilize M0 as Core.

TI 8051

Texas Instrument's 8051 utilizes the CISC (Complex Instruction Set) architecture and is an 8-bit processor [10]. The TI CC2541 [11], for example, integrates the 8051 Core with the BLE capability at 2.4GHz using SoC, at a relatively much lower cost of 1.59$/1ku.

Implementation of Microcontroller into the System

One way of implementing the MCU into the whole wearable device system is through the WEAMS [6] (Wireless and Wearable Event Detection and Adherence Monitoring System). The microcontroller is to be integrated with other signal detection or transmission devices (such as a Bluetooth headset board), and form a PCB board altogether. The board is to be connected with all sensors and a sensor amplifier circuit board to form a complete wearable device platform.

References

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