Esperto Watch

Hardware Design Description (HDD)

Revision History

|  |  |  |  |
| --- | --- | --- | --- |
| Revision | Date | Description | By |
| 2.1 | 20-08-2018 | Version 2 Initial draft | Daniel De Sousa |
|  |  |  |  |

# Project Introduction

The Esperto Watch is a wearable platform in the form of a smart watch which is powerful enough for researchers and developers to use in their professional work yet simple enough for beginners to learn with. The platform is equipped with numerous sensors to detect biometric data such as a users heart rate or step count, wireless communication, and a companion mobile and web application to track user metrics.

The watch firmware is fully customizable, allowing developers to build onto our custom algorithms, build their own, or add features such as GPS, activity tracking, or Wi-Fi.

**Figure 1:** The Esperto Watch

# System Overview

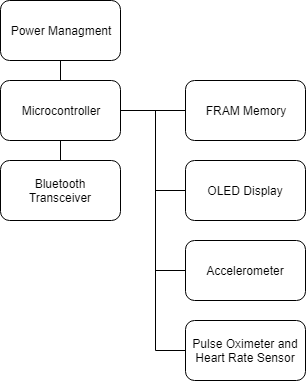
## Feature Overview

The Esperto Watch supports the following features:

* Time tracking, heart rate detection, step detection, SpO2 calculation
* Firmware upgrades / debugging over micro USB (also available over SWD)
* Battery charging
* FRAM user data storage (non-volatile)
* Bluetooth Low Energy communication for use with a mobile application
* Data synchronization between device and mobile application (heart rate, step count, SpO2)
* Mobile notifications (texts, calls)
* Displaying time, device status, mobile notifications, heart rate, and number of steps taken

## Block Diagram

These features are supported by implementing specialized sensors in the hardware and developing algorithms to obtain data from these sensors, filter the data, and convert the raw data into user metrics. A general system block diagram can be seen in **Figure 2.**



**Figure 2:** Esperto Watch General System Diagram

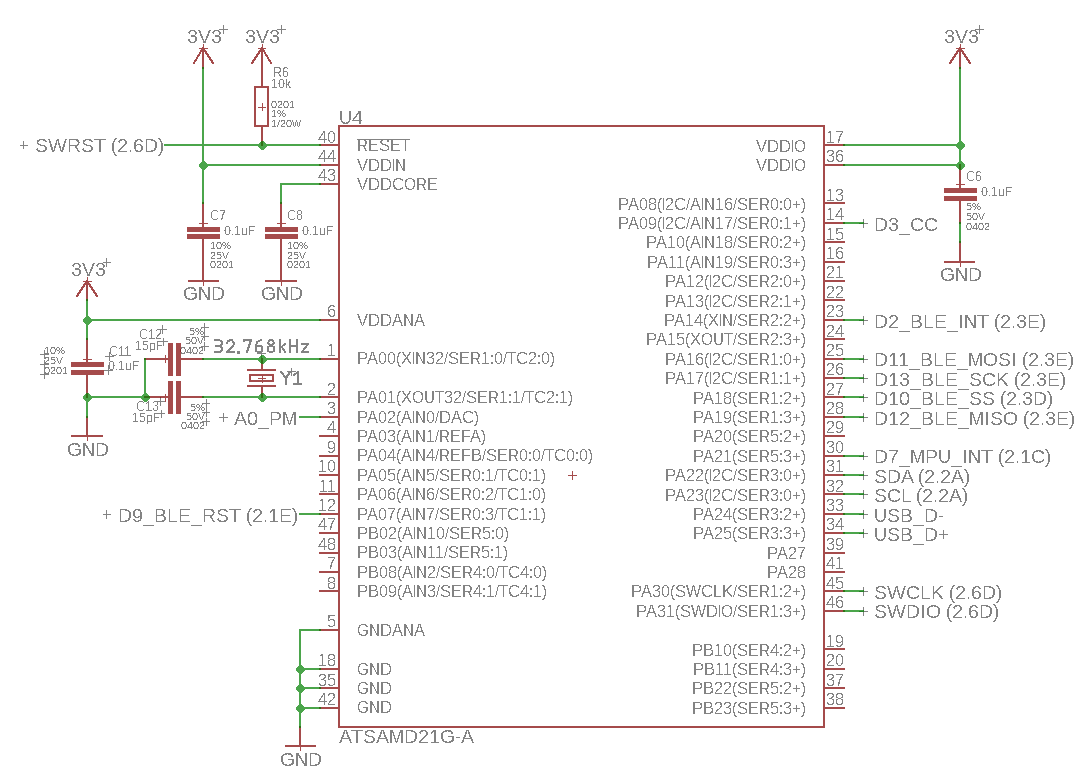
# Main Application

## Microcontroller

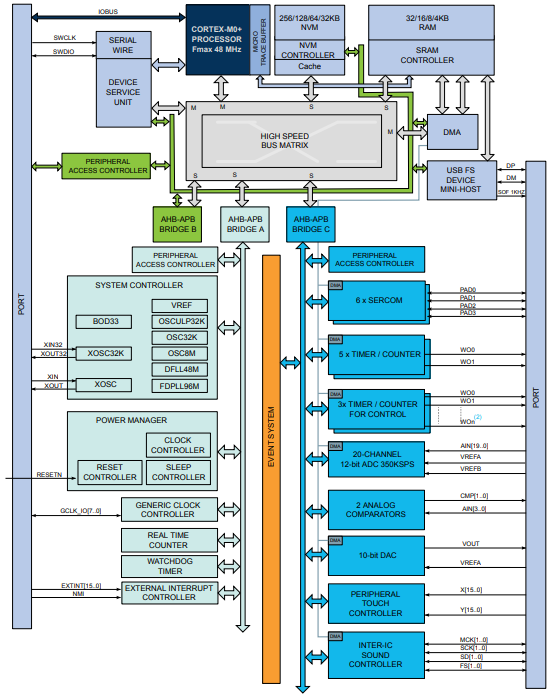
The Esperto Watch microcontroller is the SAMD21G18 by Atmel. The SAMD21 is a ARM Cortex M0+ flash-based controller running at a CPU speed of 48 MHz. It has the following features:

* 256 KB of embedded flash and 32 KB of SRAM
* Low power consumption at less than 70 uA/MHz
* 6 serial communication modules (SERCOM) supporting interfaces including SPI, USART, I2C
* Embedded full speed USB device and host capable of up to 12Mbps throughput
* 14 12-bit, 350ksps ADC channels and 1 10-bit DAC channel
* Internal 32-bit Real Time Clock (RTC) with calendar functionality
* 256 channel Peripheral Touch Controller (PTC)
* 12 Direct Memory Access controllers (DMAC)
* CRC-32 generator
* Watchdog Timer (WDT)

The Esperto Watch schematic for the microcontroller can be found in **Figure 1** whereas a system diagram block diagram of the SAMD21 can be seen in **Figure 2.**



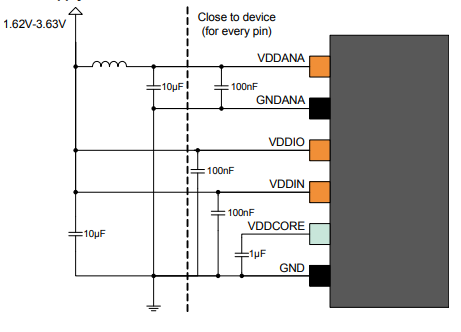
**Figure 1:**



**Figure 2:**

### Power Supply

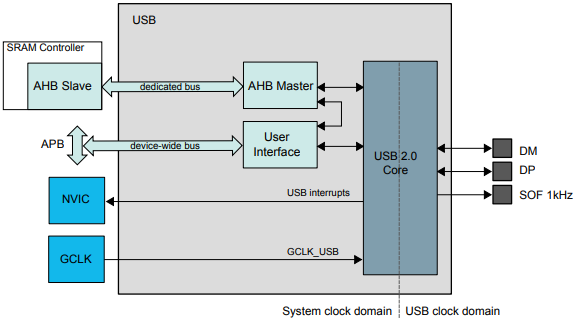
The SAMD21 uses one single main supply ranging from 1.62 V to 3.63 V. The recommended schematic is seen in **Figure 3.** The capacitor connected to VDDIN is equivalent to C6, C11 and C7 connected to the supply input, the IO input, and analog input in **Figure 1.** Their purpose is to decouple high frequency noise between the output of the regulator and the input of the microcontroller. Similarly, the capacitor connected to VDDCORE is used for the internal regulator and is equivalent to C8 on the schematic.



**Figure 3:**

### Programming and Debugging

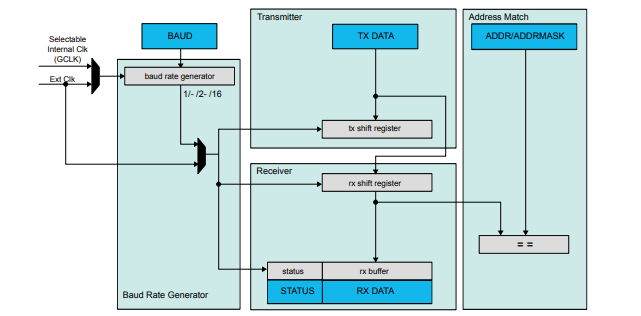
The SAMD21 uses SWD (Serial Wire Debug) to load firmware and debug the microcontroller. This interface consists of a voltage detection line used to determine the logic level, SWDIO or data line, SWCLK or the clock line, a SWRST or reset line, and a ground reference. However, a bootloader has also been written for the Esperto Watch application which allows the same functionality over the USB interface. This is possible as the SAMD21 can act as a USB 2.0 Host Device. A block diagram of the internal USB interface can be seen in **Figure 4.**



**Figure 4:**

### Serial Communication

The SAMD21 has 6 instances of the SERCOM or Serial Communication peripherals. It can be used to support an I2C, SPI, or USART bus. A single peripheral consists of a BAUD rate generator, transmitter, receiver, and an address select. The full SERCOM engine can be found in **Figure 5.**



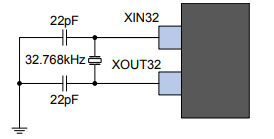
**Figure 5:**

The Esperto Watch uses the following interfaces:

* 100 KHz I2C to communicate with the OLED display, pulse oximeter FRAM, and accelerometer
* 1 MHz SPI to communicate with the BLE transceiver

### Clocks

An external 32.768 KHz crystal oscillator is used as the clock source for the internal RTC or Real Time Clock while other peripherals use the internal 8 MHz oscillator. In order to use this crystal, 2 load capacitors are required as seen in **Figure 6.**



**Figure 6:**

The capacitors in this image are equivalent to C12 and C13 in **Figure 1**. In addition to the crystal and internal circuitry of the microcontroller, the capacitors form an oscillator circuit and resonate with the crystal. This causes the crystal to oscillate on it fundamental resonance mode.

### Pinout

The following is the complete pinout of the microcontroller:

* Digital Pins
  + D2 – BLE interrupt
  + D3 – Charge complete – connected to MCP73832
  + D7 – Accelerometer interrupt
  + D9 - BLE reset
  + D10 – BLE SPI Slave Select
  + D11 – SPI MOSI
  + D12 – SPI MISO
  + D13 – SPI SCK
  + SDA – I2C Data line
  + SCL – I2C Clock line
  + USB D-
  + USB D+
  + SWCLK
  + SWDIO
* Analog
  + A0 – Connected to power monitoring circuit

## Power Management

## Pulse Oximeter and Heart Rate Sensor

## Accelerometer and Gyroscope

## Non-Volatile Memory

## OLED Display Driver

## Bluetooth Transceiver

# Notes