Activity Monitoring Solution

Activity Monitoring Overview

As global healthcare costs increase, more and more emphasis is being placed on personal health management as a means to proactively reduce the risk of health issues and, therefore, reduce the number of doctor and/or hospital visits. Tracking one's daily activity is growing in popularity due largely to its simple yet effective impact on promoting a healthy lifestyle. Extremes of activity monitoring extend from monitors such as pedometers, which track walking, running, and simple exercise, where counting steps can determine how many calories have been burned, to fall detectors, which are predominantly used for monitoring elderly people to both report and prevent falls from occurring. Besides standalone activity monitoring devices, this functionality has been integrated into a variety of home healthcare devices.

Analog Devices Inc., a Member of Continua Health Alliance

Note: Continua is dedicated to establishing a system of interoperable personal connected health solutions with the knowledge that extending those solutions into the home fosters independence, empowers individuals and provides the opportunity for truly personalized health and wellness management.

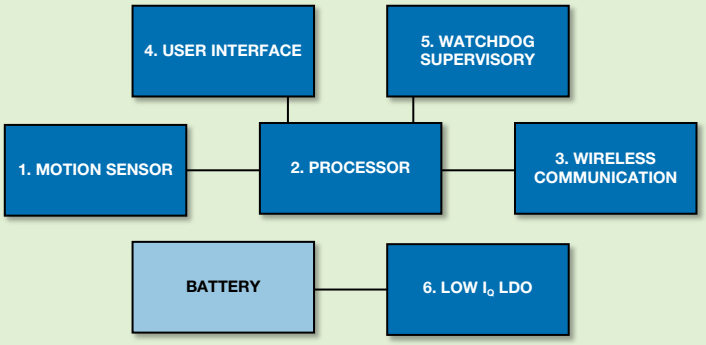
Activity Monitoring System Design Considerations and Major Challenges

This market is driven by the need to lower the overall cost of healthcare while improving patient diagnosis, care, and comfort. High performance point-of-care healthcare devices must be designed to address a number of the same requirements as their hospital or clinical counterparts, such as fail-safe features for reliable operation and user-friendly human interfaces. These devices have additional requirements that impact design, including low power consumption, smaller form factors, measurement sensitivities due to environmental conditions, industry-standard wired or wireless communication, and lower overall system cost. Types of measurements needed are also increasing, and measurements can be difficult to acquire and process. Sensor technology (for example, 3-D axis accelerometers) is important in addressing this, as well as the software algorithms employed.

- Power: Generally, activity monitoring devices are portable, sometimes even integrating into some other portable and handheld equipment. This means battery supply is one of the basic requirements, so designers have to consider the whole system's power consumption, not only select low power components, and need to consider whether parts have built-in functions that can save system power. For example, accelerometers with activity and inactivity interrupt can be used as the motion switch to power up and down the solution; embedded FIFO enables longer sleep time for process. Some tricky designs may need to trade off power and performance.
- Precision: Even though some activity monitoring devices are not used for diagnostic functions, they still need high accuracy sensors, conditioning circuits, and optimized algorithms to realize precise measurements. For example, in a pedometer application, precision performance can avoid losing steps when the user walks slowly. In a fall detection or monitoring system for the elderly, the wrong measurement or calculation can potentially cause an error alarm or lost alarm, sometimes with serious consequences.
- Miniaturization: Although most activity monitoring devices need to have low power consumption and high accuracy, the designer still needs to consider the miniaturization of the design for portability and easy integration with other activity monitoring equipment and functions by selecting electronic components designed for easy integration.
- Algorithms: In addition to hardware, optimized algorithms can be a challenge for designers. There are many tricks to implement the measurement, monitoring, and communication. The software development can sometimes take much more design time than the hardware.

ADI's product and solution advances in power, accuracy, and integration have allowed system designers to migrate to smaller, high accuracy, lower cost, more portable, higher performance solutions. The challenge moving forward is to continue to drive the system level solutions rather than only addressing the component level. ADI provides complete demonstration systems combining the hardware design and software algorithms. For example, ADI and its 3rd parties develop complete solutions for pedometers, fall detection, and other activity monitoring solutions and demonstration systems, which can be used by qualified customers to reduce their system design cycle.

Typical Activity Monitor Functional Diagram



1. Motion Sensor (MEMS)	2. Processor (MCU/DSP)	3. Wireless (ISM Band Transceiver)	4. User Interface (Capacitive-to-Digital Controllers)	5. Watchdog/ Supervisory	6. LDO
ADXL346/ ADXL345/ ADXL335	ADuCRF101/ ADuC7124/ ADuC7126/ ADSP-BF592	ADuCRF101/ ADF7023/ ADF7242	AD7147/ AD7147A/ AD7148/ AD7156	ADM13305/ ADM1184/ ADM6320/ ADM1813	ADP121/ ADP122/ ADP150/ ADP323

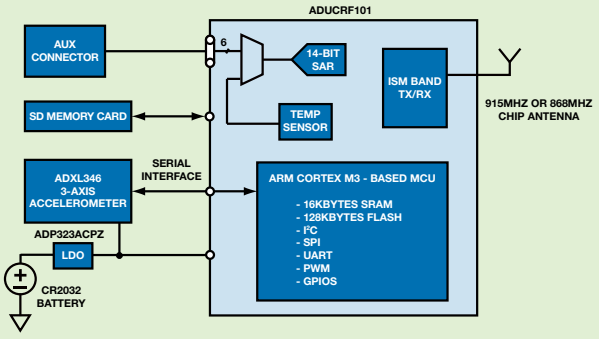
Note: The signal chain above is representative of a typical Activity Monitoring Solution. The technical requirements of the blocks vary, but the products listed in the table are representative ADI's solutions that meet some of those requirement.

Introduction of Main Products for Activity Monitoring Applications

Part Number	Description	Benefits
MEMS Accelerometer		
ADXL346	Small, thin, ultralow power, 3-axis accelerometer with high resolution (13-bit) measurement at up to ±16 *g*. Output is formatted as 16-bit; power supply 1.7 V to 2.75 V.	Well suited for mobile device applications, such as consumer ECG. Low power modes can reduce power consumption; lower operation voltage will extend battery life.
ADXL345	Small, thin, ultralow power, 3-axis accelerometer with high resolution (13-bit) measurement at up to ±16 *g*. Output is formatted as 16-bit; power supply 2.0 V to 3.6 V.	Well suited for mobile device applications, such as consumer ECG. Low power modes can reduce power consumption.
Precision Analog Microcontroller		
ADuCRF101	A fully integrated SoC solution that includes an energy efficient 431 MHz to 464 MHz and 862 MHz to 928 MHz internal UHF transceiver, low power ARM Cortex-M3 core, and Flash/ EE memory. The transceiver consumes only 12.8 mA in receive mode, while maintaining a typical sensitivity of –107.5 dB at 38.4 Kbps (2FSK). The transmit mode is equally efficient, with supply current as low as 9 mA, depending on the user programmed RF power level. The device operates directly from a 3.6 V battery and utilizes an autonomous packet handler to minimize system current consumption during wireless communications.	SoC (system-on-chip) is suitable with portable devices with high integration. Low power consumption extends battery life. Easy to integrate to other devices.
Processor		
ADuC7xxx	Precision analog microcontroller, 12-bit analog I/O, ARM7TDMI MCU; ADUC7124/ADUC7126 (large flash/SRM, 126 kB/32 kB).	SoC, higher integration, MCU benefit small size applications; larger memory for data storage.
ADSP-BF592	The ADSP-BF592 is the low cost entry point into the Blackfin® portfolio of processors. Features 400 MHz core clock speed and a peripheral set.	High data processing capability and flexible peripheral interface. Low cost to reduce BOM cost.
Capacitance-to-Digital Converter		
AD7147	An integrated CDC with on-chip environmental calibration. 13 inputs channeled through a switch matrix to a 16-bit, 250 kHz sigma-delta ADC.	High integration for implementing buttons, scroll bars, and wheels. Sensor needs one PCB layer for ultrathin systems.
RF/IF ICs		
ADF702x	High performance ISM and licensed band transceivers.	Allows device to operate in the presence of strong interferers with high sensitivity, low power consumption.
Power Manager		
ADP323	1.8 V to 5.5 V input range, triple, 200 mA, low noise, high PSRR voltage regulator, adjustable output.	High PSRR, low noise, low quiescent current, and low dropout voltage to extend the battery life of portable devices and ideally suited for wireless applications with demanding performance and board space requirements.
ADP122/ ADP123	5.5 V input, 300 mA, low quiescent current, CMOS LDO.	Low I_Q for high accuracy, easy to use.
ADP150	An ultralow noise (9 μV), low dropout, linear regulator that operates from 2.2 V to 5.5 V and provides up to 150 mA of output current.	Low 105 mV dropout voltage at 150 mA load improves efficiency and allows operation over a wide input voltage range. Low noise is suitable for high accuracy system power supply.

Demonstration System

The full-featured 3-axis accelerometer and wireless pedometer demonstration system relies on MEMS inertial sensors, ARM Cortex™-M3 precision analog microcontroller, ISM band transceiver, and software algorithms to reliably detect true steps under many use cases, such as pocket, hip, and ankle pedometer. ADI's MEMS inertial sensors permit more accurate detection of steps and fewer false positives combined with distance, speed, and calories burned by simple adjustment of the current design.



Wireless ADXL346 and ADuCRF101 Motion Sensing Platform

Wireless Data Displayed in LabVIEW through Antenna and USB Interface

Note: For more information on the complete demonstration system, please contact ADI directly.

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