



InvenSense Inc.
1197 Borregas, Sunnyvale, CA 94089 U.S.A
Tel: +1 (408) 988-7339 Fax: +1 (408) 9888104
Website: www.invensense.com

Document Number: AN-MPU-9150IMF-01
Revision: 1.0
Release Date: 09/18/2012

MPU-9150™ MotionFit™ Reference Board User Guide



Table of Contents

REVISION HISTORY	3
1 PURPOSE	4
2 REFERENCE DOCUMENTS AND SOFTWARE PACKAGES	4
3 DESCRIPTION	4
3.1 INVENSENSE NINE-AXIS MOTIONTRACKING DEVICE (MPU-9150).....	5
3.2 EMBEDDED MICROCONTROLLER (MSP430).....	5
3.3 BLUETOOTH MODULE (BR-C46AR)	5
3.4 PRESSURE SENSOR (BMP085).....	5
3.5 SERIAL FLASH	5
4 SYSTEM BLOCK DIAGRAM	6
5 BOARD HARDWARE DESIGN	7
5.1 SCHEMATICS	7
5.2 PCB LAYOUT:	8
5.3 POWER SUPPLY:.....	8
6 INSTALLATION GUIDE	9
6.1 HARDWARE AND SOFTWARE SETUP	9



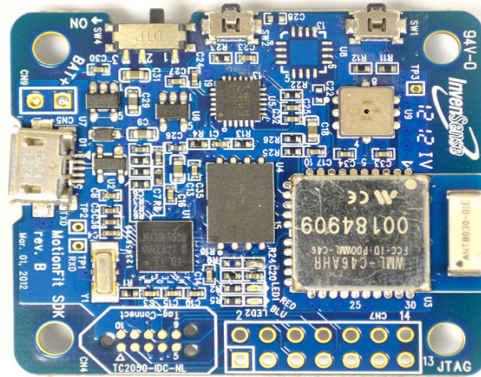
Revision History

Revision Date	Revision	Description
09/18/12	1.0	Initial Release



1 Purpose

The InvenSense MotionFit™ SDK is designed to enable rapid commercialization of wearable sensor solutions for fitness, health, and sports applications. It delivers a sensor platform capable of tracking 10-degrees-of-freedom by combining the MPU-9150 9-axis MotionTracking device, pressure sensor, microcontroller, Bluetooth radio module, serial flash, a rechargeable battery, and battery charger that is ideal for developing wearable sensor applications.



2 Reference Documents and software packages

- 2.1 **InvenSense MotionFit™ 5.1 SDK User Guide:** This document covers details on bringing up MotionFit™ SDK.
- 2.2 **MotionFit™ SDK v5.1 APIs Specification:** This document covers the Embedded MotionApps specification and functional modules.
- 2.3 **MotionFit with eMPL 5.1 release package:** This is the firmware which is running Embedded MotionApps v5.1
- 2.4 **Teapot application software package:** This is the application program running on the PC which can be used to run the MotionFit™ SDK demonstration.

3 Description

The MotionFit™ SDK provides a total solution encompassing hardware and software, with a full ten degrees of freedom from the InvenSense MotionTracking™ device, the MPU-9150. The sensors are interfaced via the I²C serial digital interface to an MSP430 MCU. A Bluetooth radio module that enables wireless connectivity is interfaced through the UART to the MCU. There is a serial flash that interfaces to the MCU using the SPI interface. Also included, is a 110mA-hr rechargeable battery and charger circuitry, that can provide up to 4 hours of wireless data streaming. Streaming is supported through the wireless interface, and a micro USB connector provides a wired interface to the SDK. The SDK is well suited for embedded applications such as activity detection for fitness, sports performance, and medical applications such as rehab and outpatient



monitoring. The board provides everything you need for sensing and communication. The following components are incorporated into this development board, and detailed explanations of their operation can be obtained from the relevant partner's component data sheets.

3.1 InvenSense Nine-Axis MotionTracking Device (MPU-9150)

MPU-9150 is a single-chip, digital output, nine-axis MEMS gyroscope, accelerometer, and compass IC optimized for wearable sensor applications. The integrated Digital Motion Processor (DMP™) inside the chip can perform 9-axis MotionFusion™ inside the MPU. The chip supports an I²C interface for connecting to the MCU. The on chip temperature sensor can enable software temperature compensation for the gyro bias. The embedded AK8975 compass sensor die incorporates magnetic sensors for detecting terrestrial magnetism in the X-axis, Y-axis, and Z-axis. The MPU-9150 contains a sensor driving circuit, a signal amplifier chain, and an arithmetic circuit for processing the signal from each sensor.

3.2 Embedded Microcontroller (MSP430)

The Texas Instruments MSP430 family of ultra-low power microcontrollers consists of several devices featuring different sets of peripherals targeted for various applications. The architecture, combined with extensive low-power modes, is optimized to achieve extended battery life in portable measurement applications. The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in 3.5 μs (typical). The MSP430F5528IZQE, has an integrated USB and PHY supporting USB 2.0, four 16-bit timers, a high-performance 12-bit analog-to-digital converter (ADC), two universal serial communication interfaces (USCI), hardware multiplier, DMA, real-time clock module with alarm capabilities, and 63 I/O pins.

3.3 Bluetooth module (BR-C46AR)

- The Bluetooth radio module can be configured, commanded, and controlled through simple ASCII strings over the Bluetooth RF link or directly through the hardware serial UART.
- Dedicated PCM voice channel for audio applications, and eSCO for exceptional audio clarity.
- UART baud rate speeds: 1200bps up to 921.6Kbps.
- Supports up to 10 meter (33 feet) distance.
- Low power consumption (50mA TX, 40mA RX, 1.4mA idle mode, and 30uA deep sleep).
- Small-form factor SMT radio modem.
- Operating temperature range: -40~+85°C.
- Secure and robust communication link.
 - FHSS (Frequency Hopping Spread Spectrum).
 - Encryption and 16 alphanumeric Personal Identification Numbers (PIN).
 - Error correction schemes.

3.4 Pressure Sensor (BMP085)

The BMP085 is based on piezo resistive technology for EMC robustness, high accuracy, linearity, as well as long term stability. The ultra-low power, low voltage electronics of the BMP085 is optimized for use in battery operated applications. With a low altitude noise of merely 0.25m at a fast conversion time, the BMP085 offers superior performance. The I2C interface offers easy integration with the MCU.

3.5 Serial Flash

The MotionFit™ SDK has a 256Mbit serial flash integrated for storing activity data.

4. System Block Diagram

Figure 1 displays the MotionFit SDK system block diagram.

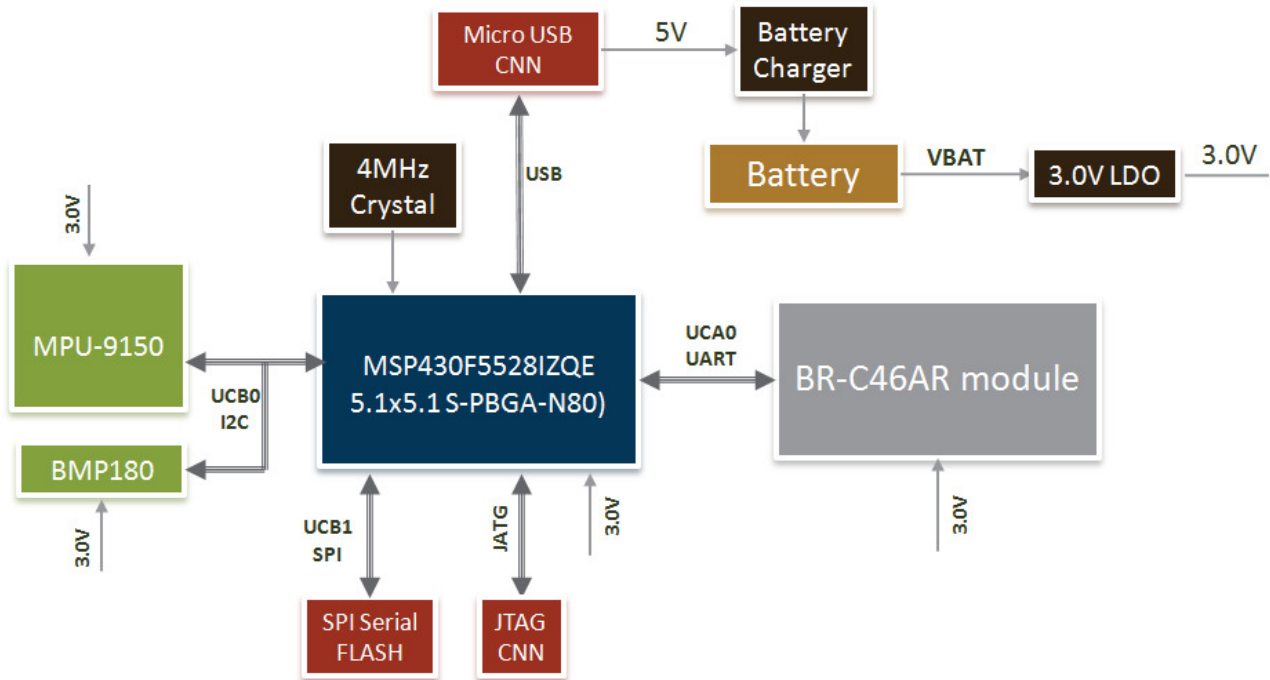


Figure 1 System Block Diagram

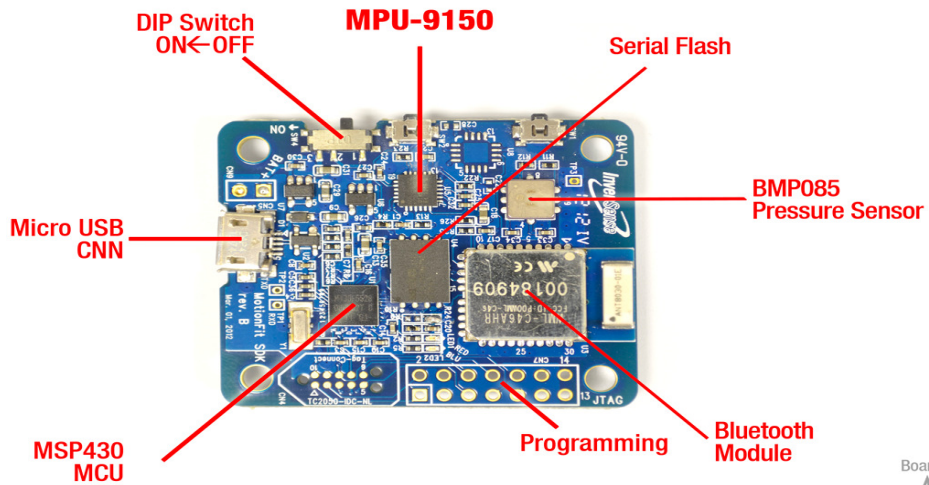


Figure 2 Components on Board

5 Board Hardware Design

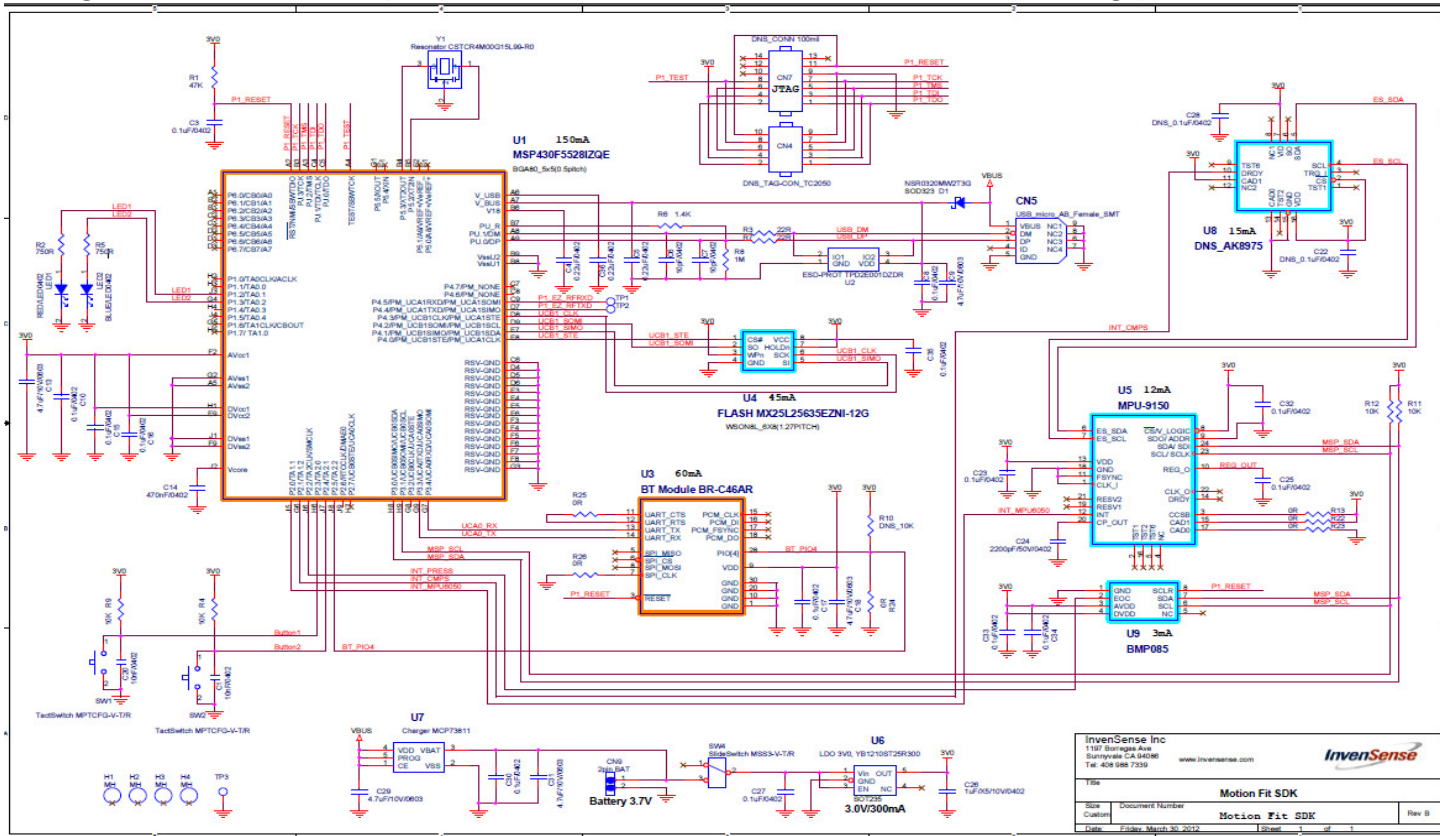
5.1 Schematics

Table 1 gives the I2C addresses for sensors. Figure 3 shows the schematic for the MotionFit SDK board.

Sensor	7 bit I2C Slave Address
MPU-9150	0x68
BMP085	0x77

Table 1 Sensor I2C Device Address

Figure 3 Board Schematic. (Also Located in the MotionFit with eMPL 5.1 Release Package)



5.2 PCB Layout:

Figure 4 shows the PCB layout and board dimensions for the MotionFit™ SDK board.

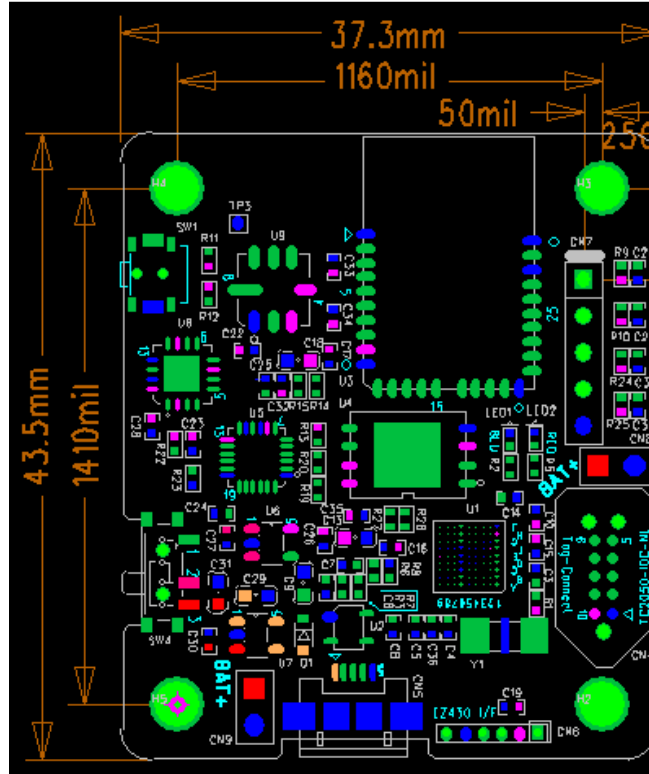


Figure 4 MotionFit™ SDK board layout

5.3 Power supply:

The MotionFit™ SDK board is powered by a 3.7V Lithium-ion rechargeable battery. The battery is charged through a micro USB connector. An on board 3.0V LDO provides power supply to all ICs. The slide switch SW4 allows board power to be switched on and off.



6 Installation Guide

6.1 Hardware and Software Setup

Please refer to the InvenSense MotionFit 5.1 SDK User Guide for hardware and software setup instructions.

This information furnished by InvenSense is believed to be accurate and reliable. However, no responsibility is assumed by InvenSense for its use, or for any infringements of patents or other rights of third parties that may result from its use. Specifications are subject to change without notice. InvenSense reserves the right to make changes to this product, including its circuits and software, in order to improve its design and/or performance, without prior notice. InvenSense makes no warranties, neither expressed nor implied, regarding the information and specifications contained in this document. InvenSense assumes no responsibility for any claims or damages arising from information contained in this document, or from the use of products and services detailed therein. This includes, but is not limited to, claims or damages based on the infringement of patents, copyrights, mask work and/or other intellectual property rights.

Certain intellectual property owned by InvenSense and described in this document is patent protected. No license is granted by implication or otherwise under any patent or patent rights of InvenSense. This publication supersedes and replaces all information previously supplied. Trademarks that are registered trademarks are the property of their respective companies. InvenSense sensors should not be used or sold in the development, storage, production or utilization of any conventional or mass-destructive weapons or for any other weapons or life threatening applications, as well as in any other life critical applications such as medical equipment, transportation, aerospace and nuclear instruments, undersea equipment, power plant equipment, disaster prevention and crime prevention equipment.

The information in this document is preliminary and subject to change without notice. InvenSense assumes no liability for infringement of any patent, intellectual property or use of any information contained herein. InvenSense, MotionTracking, MotionProcessing, MotionProcessor, Nasiri-Fabrication, MotionFusion, MotionApps, MotionFit, DMP, and the InvenSense logo are trademarks of InvenSense, Inc. Other company and product names may be trademarks of the respective companies with which they are associated.

©2012 InvenSense, Inc. All rights reserved.

