Using the Wireless Sensing Triple Axis Reference Design

RD3152MMA7260Q Reference Design (ZSTAR)

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The Wireless Sensing Triple Axis Reference Design (ZSTAR) is a wireless successor of the popular STAR board described in AN3112 (RD3112MMA7260Q). It is an improved demonstration tool that is designed to allow visualization of key accelerometer applications in the consumer industry as well as the low-cost 2.4 GHz wireless solution based on the MC13191 transceiver.

The ZSTAR is a two-board design where a MMA7260QT triple axis accelerometer is controlled by an 8-bit MCU MC9S08QG8 and connected via a wireless link to a computer. The USB stick connects via the computer's USB slot. For the USB communication, a Full-Speed USB 2.0 8-bit microcontroller MCHC908JW32 is employed.

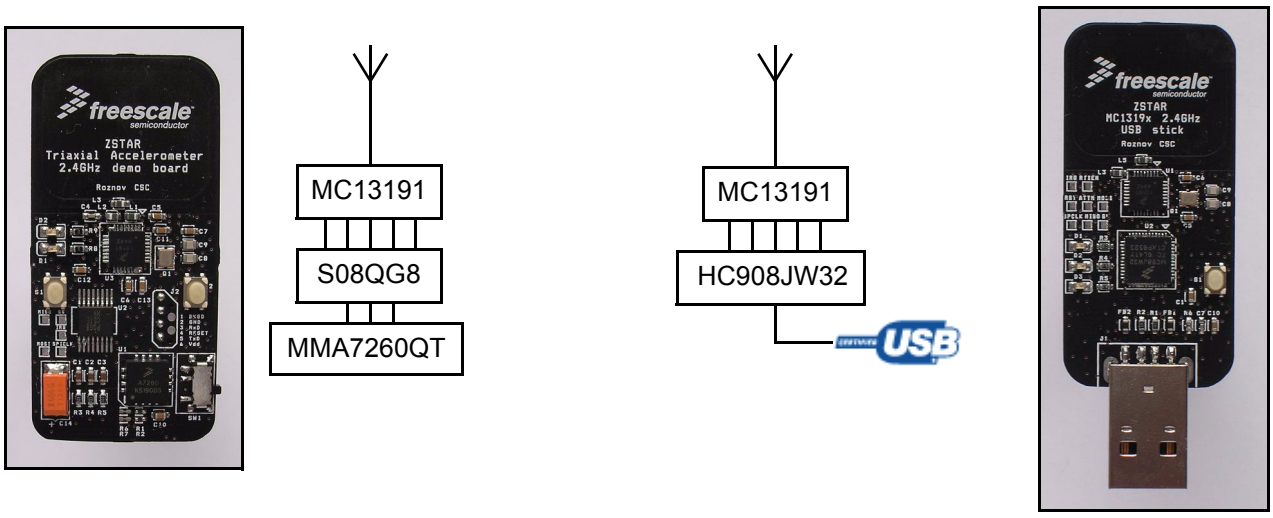

Figure 1. ZSTAR Design Overview

FEATURED PRODUCTS

This demo consists of several Freescale products. The main features are listed below.

Triple Axis Accelerometer MMA7260QT

The ZSTAR board is a demonstration tool for the MMA7260QT, a 3-Axis Low-g accelerometer. The MMA7260QT has many unique features that make it an ideal solution for many consumer applications such as freefall protection for laptops and MP3 players, tilt detection for e-compass compensation and cell phone scrolling, motion detection for handheld games and game controllers, position sensing for g-mice, shock detection for warranty monitors, and vibration for out of balance detection.

Features such as low power, low current, and sleep mode with a quick turn-on time allow the battery life to be extended in end applications. The 3-axis sensing in a small QFN package requires only 6 mm x 6 mm board space, with a profile of 1.45 mm, allowing for easy integration into many small handheld electronics.

There are several other derivatives of MMA7260QT:

- MMA7261Q XYZ triple axis accelerometer with selectable 2.5g to 10g range
- MMA6270Q XY dual axis accelerometer with selectable 1.5g to 6g range
- MMA6271Q XY dual axis accelerometer with selectable 2.5g to 10g range
- MMA6280Q XZ dual axis accelerometer with selectable 1.5g to 6g range
- MMA6281Q XZ dual axis accelerometer with selectable 2.5g to 10g range

All members of this sensor family are footprint (QFN package) compatible, which simplifies the evaluation and design of the target application.

Microcontroller MC9S08QG8

The MC9S08QG8 is a highly integrated member of Freescale's 8-bit family of microcontrollers based on the high-performance, low-power consumption HCS08 core. Integrating features normally found in larger, more expensive components, the MC9S08QG8 MCU includes a **background debugging system** and on-chip in-circuit emulation (ICE) with real-time bus capture, providing single-wire debugging and emulation interface. It also features a programmable 16-bit timer/pulse-width modulation (PWM) module (TPM) that is one of the most flexible and cost-effective of its kind.

The compact, tightly integrated MC9S08QG8 delivers a versatile combination and wealth of Freescale peripherals and the advanced features of the HCS08 core, including **extended battery life** with maximum performance down to 1.8 V, industry-leading Flash and innovative development support. The MC9S08QG8 is an excellent solution for power and size-sensitive applications, such as wireless communications and handheld devices, small appliances, Simple Media Access Controller (SMAC)-based applications and toys.

MC9S08QG8 Features

- Up to 20 MHz operating frequencies at >2.1 volts and 16 MHz at <2.1 volts
- 8 K Flash and 512 bytes RAM
- Support for up to 32 interrupt/reset sources
- 8-bit modulo timer module with 8-bit prescaler
- Enhanced 8-channel, 10-bit analog-to-digital converter (ADC)
- Analog comparator module
- Three communication interfaces: SCI, SPI and IIC

MC13191 2.4 GHz ISM Band Low Power Transceiver

The MC13191 is a short range, low power, 2.4 GHz Industrial, Scientific, and Medical (ISM) band transceiver. The MC13191 contains a complete packet data modem which is compliant with the IEEE® 802.15.4 Standard PHY (Physical) layer. This allows the development of proprietary point-to-point and star networks based on the 802.15.4 packet structure and modulation format. For full 802.15.4 compliance, the MC13192 and Freescale's 802.15.4 MAC software are required.

When combined with an appropriate microcontroller (MCU), the MC13191 provides a cost-effective solution for short-range data links and networks. Interfacing the MCU is accomplished by using a four wire serial peripheral interface (SPI) connection and an interrupt request output which allows for the use of a variety of processors. The software and processor can be scaled to fit applications ranging from simple point-to-point to star networks.

MC13192/MC13193 2.4 GHz Low Power Transceiver for the IEEE® 802.15.4 Standard

The MC13192 and MC13193 are short range, low power, 2.4 GHz Industrial, Scientific, and Medical (ISM) band transceivers. The MC13192/MC13193 contains a complete 802.15.4 physical layer (PHY) modem designed for the IEEE® 802.15.4 wireless standard which supports peer-to-peer, star, and mesh networking.

The MC13192 includes the 802.15.4 PHY/MAC for use with the HCS08 Family of MCUs. The MC13193 also includes the 802.15.4 PHY/MAC plus the ZigBee™ Protocol Stack for use with the HCS08 Family of MCUs. With the exception of the addition of the ZigBee™ Protocol Stack, the MC13193 functionality is the same as the MC13192.

When combined with an appropriate microcontroller (MCU), the MC13192/MC13193 provides a cost-effective solution for short-range data links and networks. Interfacing the MCU is accomplished by using a four wire serial peripheral interface (SPI) connection and an interrupt request output which allows for the use of a variety of processors. The software and processor can be scaled to fit applications ranging from simple point-to-point systems, through complete ZigBee™ networking.

Microcontroller MCHC908JW32

The MCHC908JW32 is a member of the low-cost, high-performance M68HC08 Family of 8-bit microcontroller units (MCUs). All MCUs in the family use the enhanced M68HC08 central processor unit (CPU08) and are available with a variety of modules, memory sizes and types, and package types.

MCHC908JW32 Features

- Maximum internal bus frequency: 8 MHz at 3.5–5 V operating voltage
- Oscillators:
  - 4 MHz crystal oscillator clock input with 32 MHz internal phase-lock loop
  - Internal 88 kHz RC oscillator for timebase wakeup
- 32,768 bytes user program FLASH memory with security feature
- 1,024 bytes of on-chip RAM
- 29 general-purpose input/output (I/O) ports:
  - 8 keyboard interrupt with internal pull-up
  - 3 pins with direct LED drive
  - 2 pins with 10 mA current drive for PS/2 connection
- 16-bit, 2-channel timer interface module (TIM) with selectable input capture, output compare, PWM capability on each channel, and external clock input option
- Timebase module
- PS/2 clock generator module
- Serial Peripheral Interface (SPI) Module
- Universal Serial Bus (USB) 2.0 Full Speed functions:
  - 12 Mbps data rate
  - Endpoint 0 with 8-byte transmit buffer and 8-byte receive buffer
  - 64 bytes endpoint buffer to share among endpoints 1–4

ZSTAR REFERENCE BOARDS

The goal of the ZSTAR design was to provide a small portable board with the capability to demonstrate and evaluate various accelerometer applications that accommodate the low-cost low-power wireless connection. One of the considerations for design was to use a small and versatile tool (board size is 56 mm x 27 mm or 2.20" x 1.10"). The Sensor board includes two PCB 2.4 GHz antennas, CR2032 Lithium battery holder and the two pushbuttons. The USB stick board has the same two PCB 2.4 GHz antennas, one pushbutton and a USB type “A” plug.

Table 1 and Table 2 provide a brief description of the components on the ZSTAR boards and Figure 2 and Figure 3 show the location on the boards.

Table 1. ZSTAR Sensor Board Components

Component	Component Function
MMA7260QT	3-axis Accelerometer part to give vibration and inertial readings to the board
MC9S08QG8	8-bit microprocessor on the Sensor board, containing the SMAC stack, which can be reprogrammed on-board over the BDM (Background Debug Interface)
MC13191	2.4 GHz Low-Power RF Transceiver used for wireless transmission
Q1 Crystal	16.0 MHz crystal that accompanies MC13191 Transceiver
SW1 Main switch	Used to power on/off the Sensor board
S1 and S2 Pushbuttons	The pushbuttons are used when the Wireless mouse demonstration is active, acting as left and right mouse buttons.
D1 and D2 Status LEDs	These LEDs provide the user feedback about the Sensor board status, Transceiver or Sleep mode activity
Transmit and Receive PCB Antennas	These small footprint antennas are designed on the opposite sides of the PCB.
CR2032 Lithium Battery Holder	Provides the power for the Sensor board (on bottom side of the Sensor board). The footprint design allows to use CR2430, CR2450 or CR2477 battery holders when larger battery capacity is required.

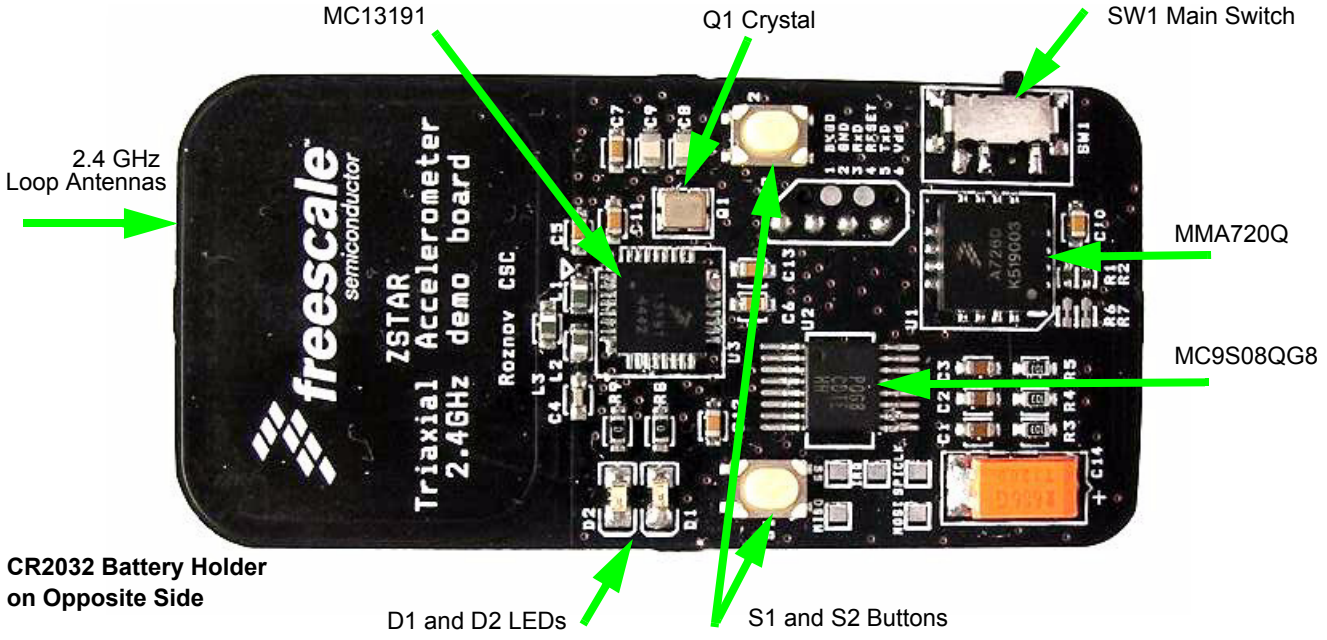

Figure 2. ZSTAR Sensor Board View

Table 2. ZSTAR USB Stick Board Components

Component	Component function
MCHC908JW32	8-bit microprocessor on the USB stick board, contains the SMAC stack and USB driver software. Its main job is bridging the received data from the Sensor board to the USB. Can be reprogrammed over the USB port.
MC13191	2.4 GHz Low-Power RF Transceiver used for wireless transmission
Q1 Crystal	16.0 MHz crystal that accompanies MC13191 Transceiver
Q2 Crystal	Q2 is the 6.0 MHz frequency reference for the MCHC908JW32 MCU
S1 Pushbutton	The pushbutton is used to change the operation mode of the USB stick (towards the PC).
D1, D2 and D3 Status LEDs	These LEDs provide the user feedback about the USB stick board status, Transceiver and USB activity
Transmit and Receive PCB Antennas	These small footprint antennas are designed on the opposite sides of the PCB
J1 USB type “A” plug	Provides the USB data connection and power from the USB slot
U3 and U4 Voltage regulator	U3 and U4 voltage regulators provide the regulated voltage for MC13191 and MCHC908JW32 out of 5.0 V voltage from USB port

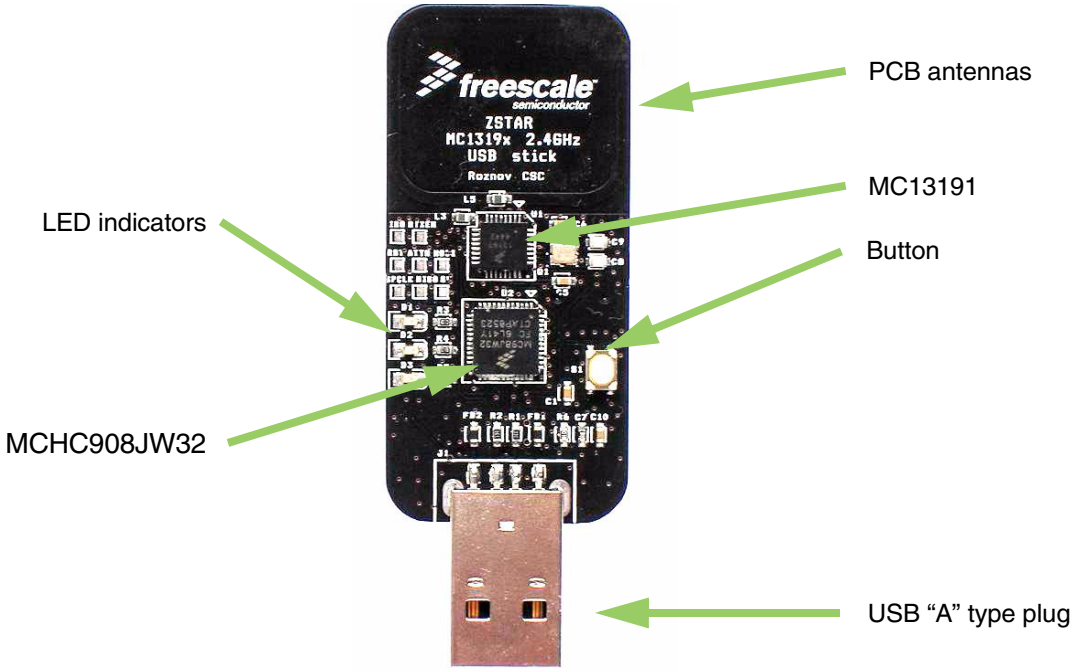

Figure 3. ZSTAR USB Stick Board View

SOFTWARE

This reference design contains two pieces of software. The first one is on the Sensor board MCU (MC9S08QG8). Its job is to collect sensor data from the MMA7260QT accelerometer, create a data packet and send it over the SMAC (Simple Media Access Controller) driver using the MC13191 RF Transceiver.

The sensor data is measured over three channels of the Analog-to-Digital converter, while another GPIO pin controls the sleep mode of the MMA7260QT accelerometer to conserve power.

Serial Peripheral Interface (SPI) is used for communication with the MC13191.

The overall application is powered from the coin-sized CR2032 Lithium battery that is located on the bottom side of the board. The overall average current consumption is below 1 mA with 20 data transmissions per second rate. This allows approximately 10 days of continuous operation at this real-time data rate.

The simple ZSTAR RF protocol also transfers the calibration data. These data are stored in non-volatile Flash memory and are transferred on request.

The software and hardware interface is shown in Figure 4.

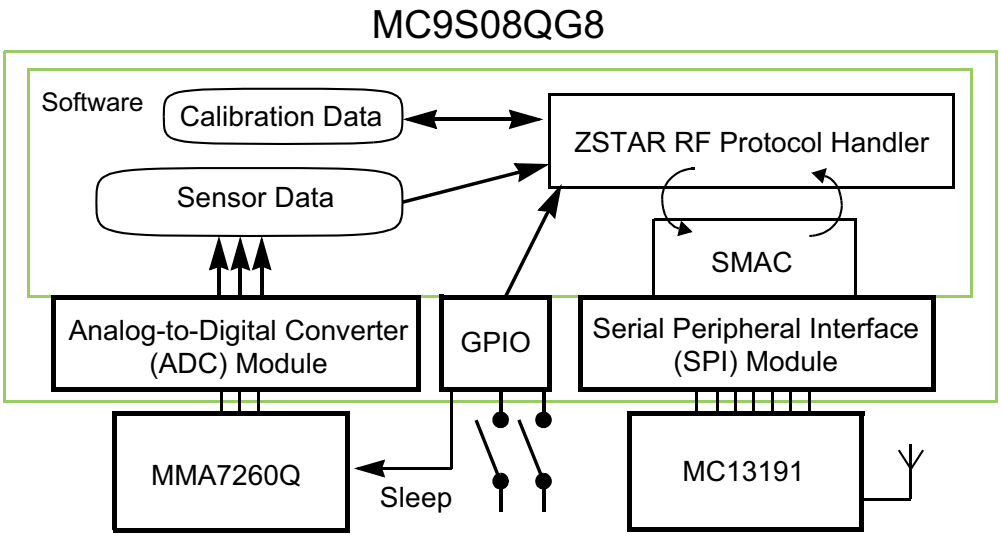

Figure 4. ZSTAR Sensor Board Software Overview

The second piece of software is contained within the USB stick board and its job is to create a “bridge” between the RF link and the USB connection. The sensor and keyboard data are received from the Sensor board and stored in the USB stick RAM memory. Another independent process is the USB protocol communication. Several options are possible. USB specifications define several ways of transferring data between the USB peripheral and the PC (called “profiles” or classes). In this demo two classes are demonstrated:

- Serial communication class (“virtual serial port”)
- HID (Human Interface Device) class

The Microsoft™ Windows 2000/XP operating system contains by default a driver support for these classes which makes this solution simple for demonstration purposes.

If the serial communication (virtual serial port) is demonstrated, the accelerometric data is available through the simple serial protocol compatible with the STAR demo. Thus most of the RD3112MMA7260QSW is usable also for data visualization.

On the other hand, if the HID class is demonstrated, the ZSTAR demo behaves as a mouse. By tilting the sensor board, the mouse cursor movement can be controlled.

The software and hardware interfacing is shown in Figure 5.

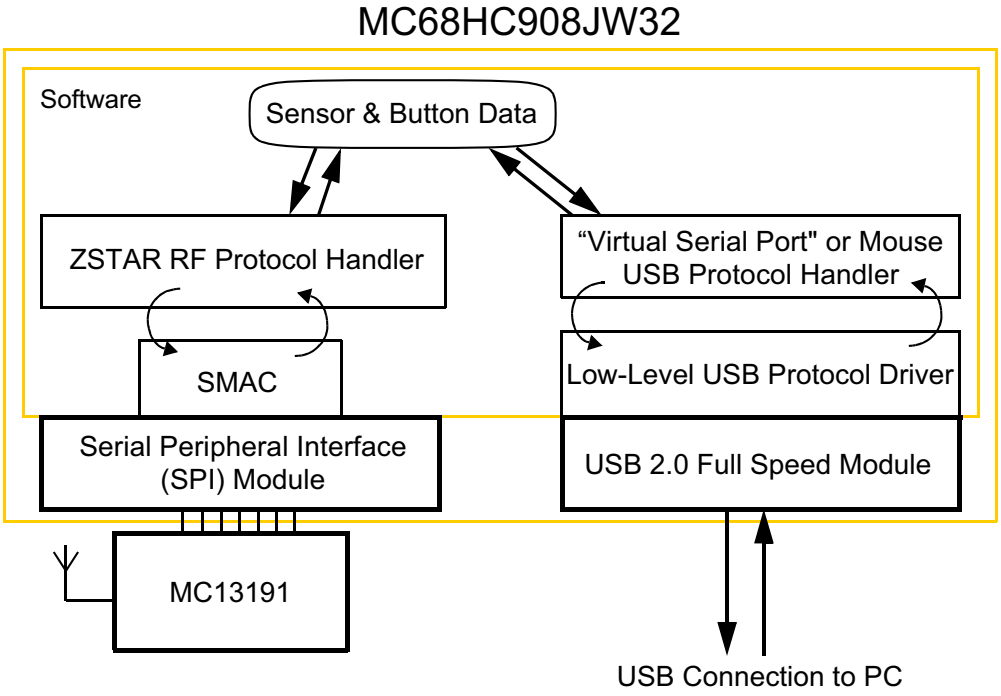

Figure 5. ZSTAR USB Stick Software Overview

SUMMARY

Multi-axis sensing using an XYZ-axis low g acceleration sensor, MMA7260QT with selectable g-ranges of 1.5g/2g/4g/6g, is combined with the versatile MC9S08QG8 8-bit microcontroller.

2.4 GHz wireless communication is enabled by the latest RFCMOS technology. The MC13191 is a member of the pin-to-pin compatible series of Freescale's transceivers, including the MC13192 which supports the IEEE 802.15.4 protocol and the MC13193 which supports full ZigBee™ compliant applications.

The USB 2.0 with the 8-bit MCHC908JW32 full speed chip offers plug and play benefits.

RD3152MMA7260Q demonstrates:

- Consumer and industrial wireless sensing applications
- Accelerometer: MMA7260QT (MMA7261QT/MMA6270QT/MMA6271QT/MMA6280QT/MMA6281QT)
  - Package: Quad Flat No-Lead (QFN) 6 x 6 x 1.45 mm
  - Power: Low Voltage 2.2 V to 3.6 V
  - Low power consumption: 500 µA (3 µA in standby mode)
  - Selective g range:
    - 1.5g, 2g, 4g, 6g (MMA7260QT/MMA6270QT/MMA6280QT)
    - 2.5g, 3.3g, 6.7g, 10g (MMA7261QT/MMA6271QT/MMA6281QT)
  - Response time: 1 ms
- Microprocessor: MC9S08QG8
  - Versatile 8-bit microcontroller
- Wireless connectivity: ZigBee™ Transceivers (MC1319x)
- Microprocessor: MCHC908JW32 (USB 2.0 Full Speed)

References

AN3112 Using the Sensing Triple Axis Reference Board (STAR)

AN1986 Using the TRIAX Evaluation Board

AN3107 Measuring Tilt with Low-g Accelerometers

AN3109 Using the Multi-Axis g-Select Evaluation Boards

AN1611 Impact and Measurement Using Accelerometers

AN2731 Compact, Integrated Antennas: Designs and Applications for the MC13191 and MC13192

SMACRM Simple Media Access Controller (SMAC) User's Guide

AN2728 Demonstration Guide for SMAC Applications

AN2295 Developer's Serial Bootloader for M68HC08 and HCS08 MCUs

APPENDIX A
ZSTAR BOARDS SCHEMATICS AND PCBs

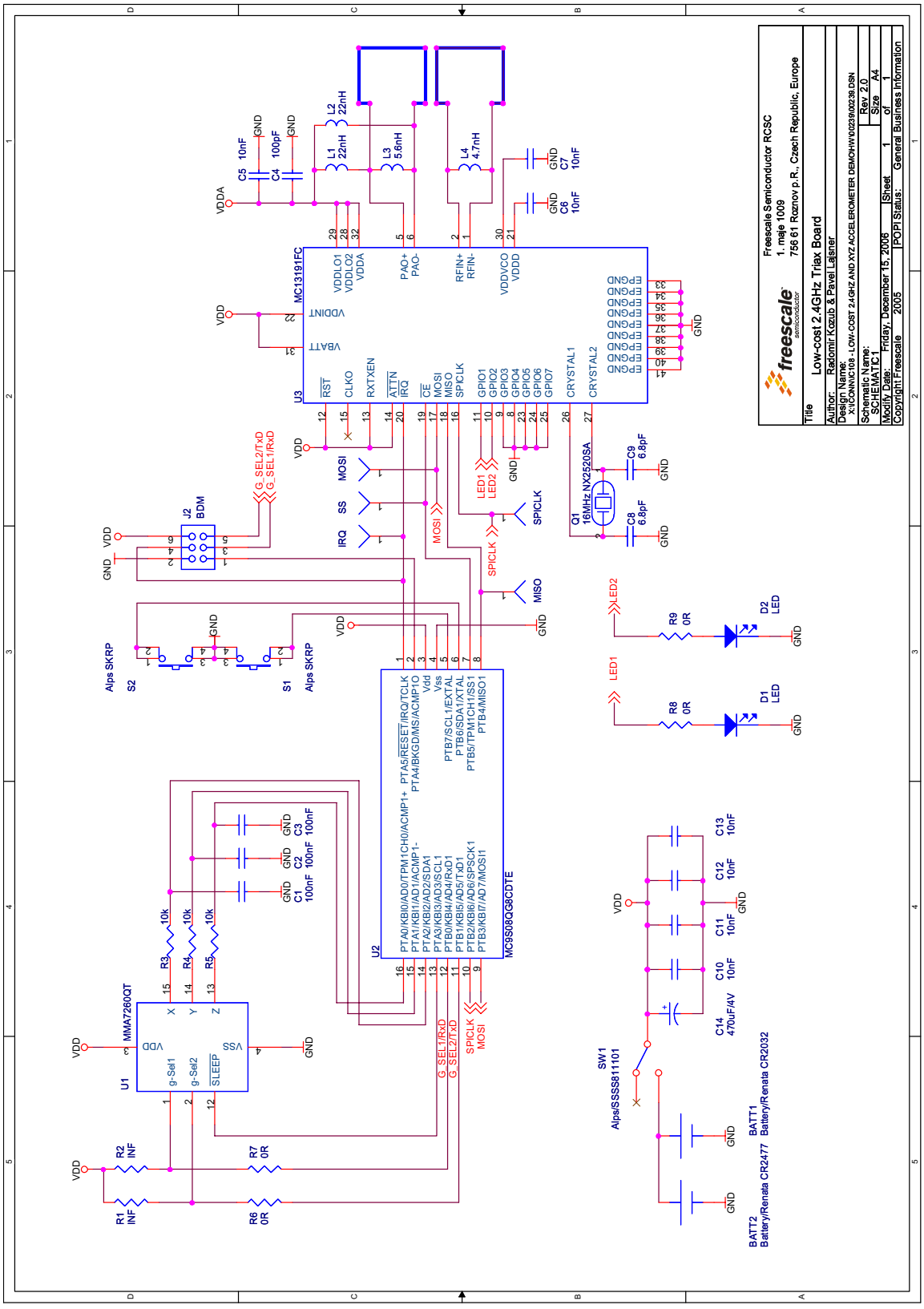

Figure 6. ZSTAR Sensor Board Schematics

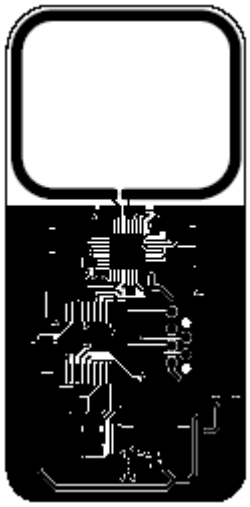

Figure 7. Top Layer of the Sensor Board

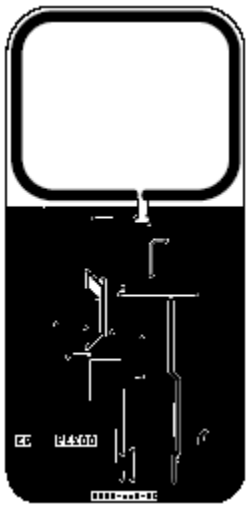

Figure 8. Bottom Layer of the Sensor Board

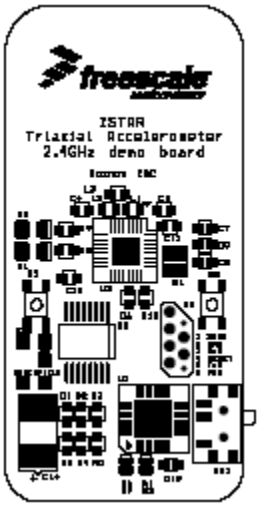

Figure 9. Top Component Placement of the Sensor Board

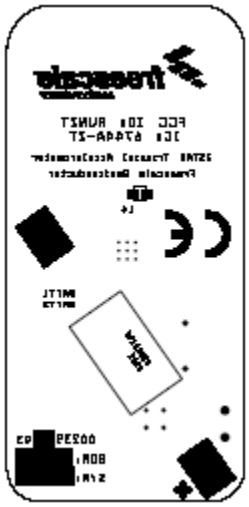

Figure 10. Bottom Component Placement of the Sensor Board

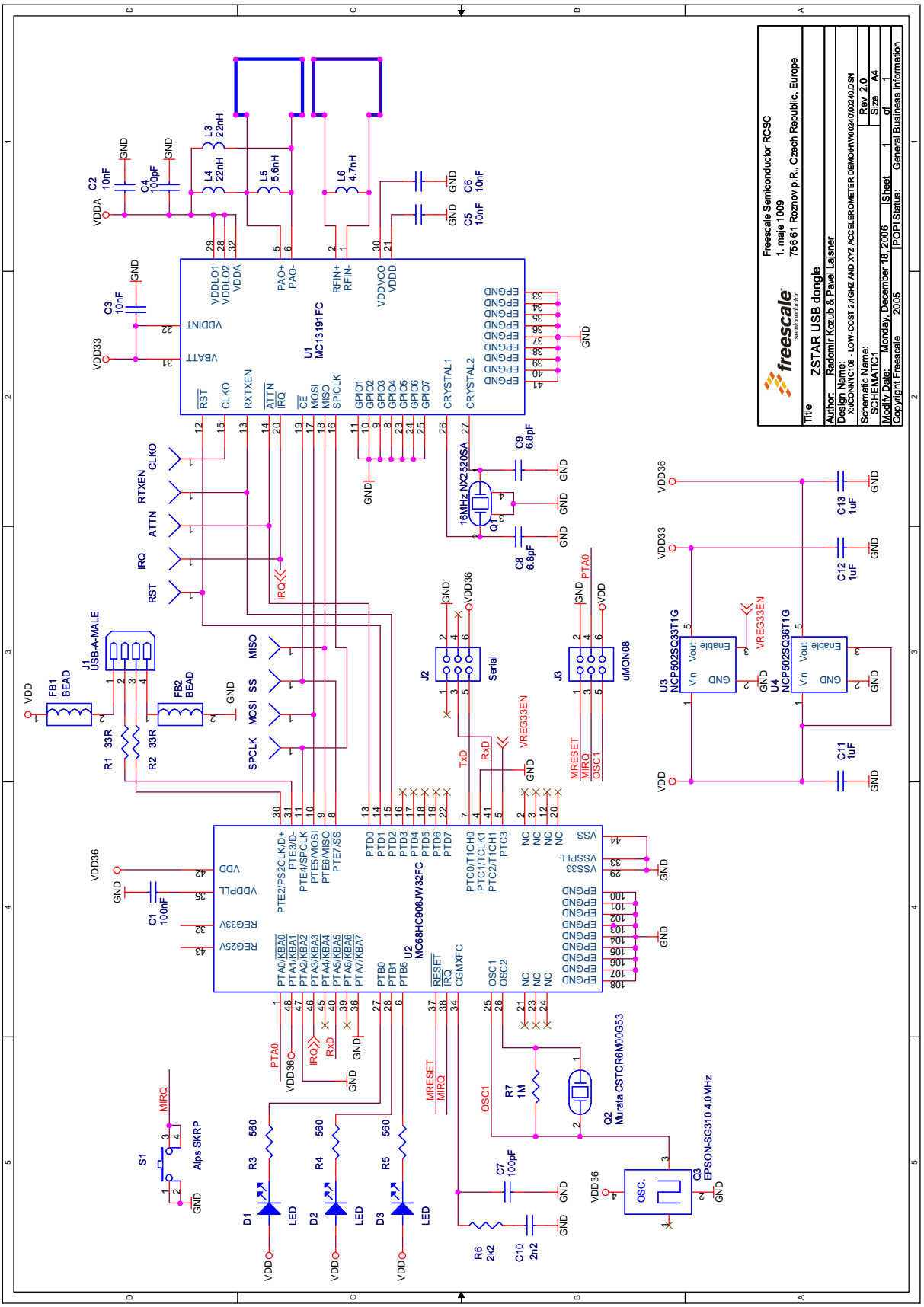

Figure 11. ZSTAR USB Stick Board Schematics

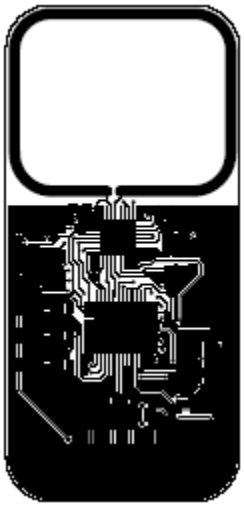

Figure 12. Top Layer of the USB Stick Board

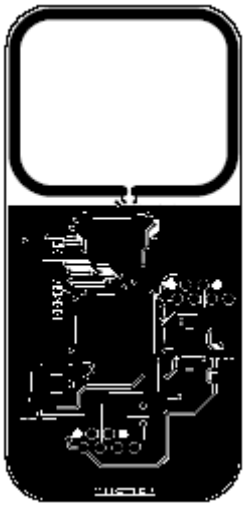

Figure 13. Bottom Layer of the USB Stick Board

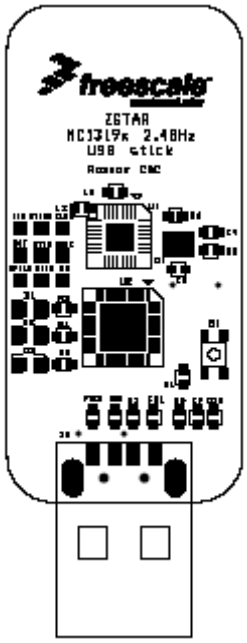

Figure 14. Top Component Placement of the USB Stick Board

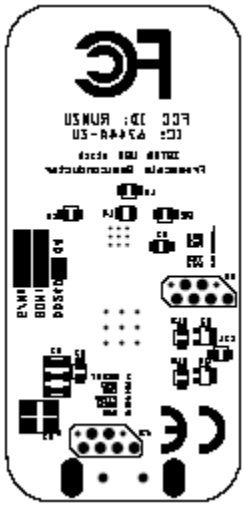

Figure 15. Bottom Component Placement of the USB Stick Board

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AN3152
Rev. 2
01/2007