ZStar3 Multiple Wireless Sensing Triple Axis Reference Design

ZSTAR3RM
Rev. 0
01/2008

freescale.com

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semiconductor

Safety of Radio Frequency Energy

The manufacturer has evaluated the transmitter for safe operation for uncontrolled use in the general population. The measured power density at 1 cm is under the threshold established by the FCC and is not required to be tested for specific absorption rate. The manufacturer instructs the user that the transmitter should not be handled or placed near the body continuously for more than 30 minutes while operating.

USA:

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

– Reorient or relocate the receiving antenna.
– Increase the separation between the equipment and receiver.
– Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
– Consult the dealer or an experienced radio/TV technician for help.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Canada:

This digital apparatus complies with Canadian ICES-003.

Cet appareil numérique est conforme à la norme NMB-003 du Canada.

Europe:

Compliant (CE)

Contents

Chapter 1
Introduction

1.1 Introduction

This paper describes the next generation of design of a Wireless Sensing Triple Axis Reference design (ZSTAR3), a demo for wireless demonstration of the 3-axes accelerometers MMA7450L (RD3172MMA7450L) and MMA7360L (RD3172MMA7360L) sensors from Freescale. This demo is succesor of previous Freescale demo ZSTAR and its fully compatible with it.Demois build on new generation of Freescale parts and brings some extended functionalities.

The reference design will enable you to see how Freescale's accelerometers can add additional functionality to applications in various industries. The accelerometer measurements can be grouped into 6 sensing functions - Fall, Tilt, Motion, Positioning, Shock and Vibration - for multifunctional applications.

The RD3172MMA7450L / RD3172MMA7360L development tool offers robust wireless communication using the powerful, easy-to-use 2.4GHz frequency transceiver and microcontroller in one package MC13213. Without any changes on board can be made with pin to pin compatibility allowing implementation of the MC13214 for ZigBeeTM wireless applications.

Only Sensor board was updated completely, as receiver is still used USB stick from previous generation of ZSTAR, but new software was developed that can support all new functionalities

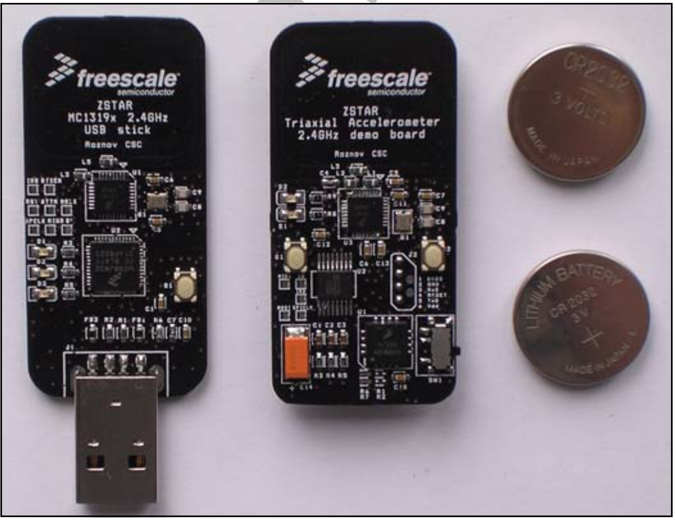


Figure 1-1. Original ZSTAR Demo photo **(CR2032 batteries for comparison)**

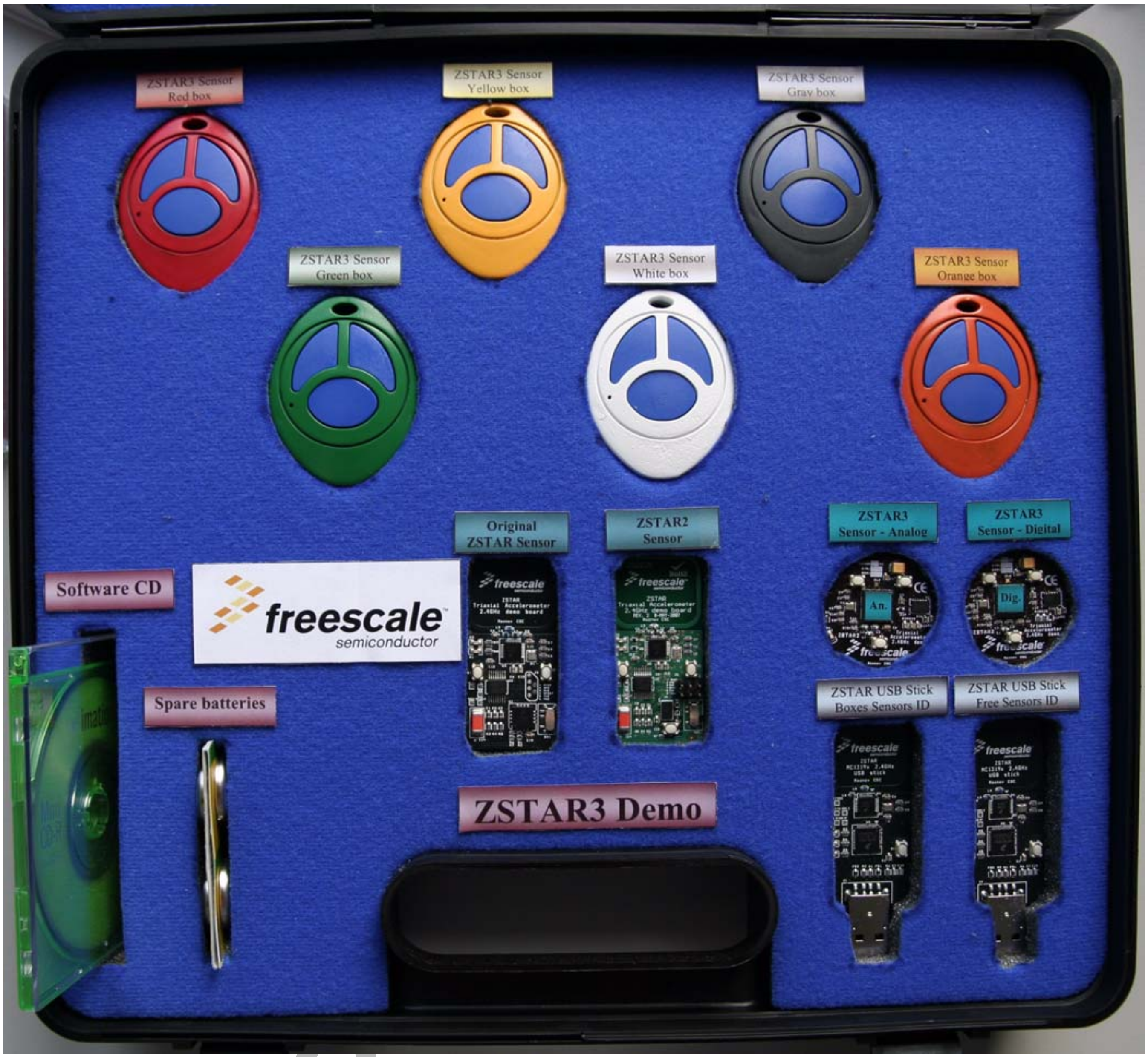


Figure 1-2. ZSTAR3 demo suitcase

Chapter 2 ZSTAR3 Wireless Sensing Triple Axis Reference design Introduction

2.1 Introduction

The Wireless Sensing Triple Axis Reference design (ZSTAR3) has been designed as a new generation of the previous ZSTAR (RD3152MMA7260Q) demo. A 2.4GHz radio-frequency (RF) link is also used in this new demo and its based on new solution modem and microcontroler in one package MC13213 family.And it’s used for connection from the Sensor to PC, allowing the visualization of key accelerometer applications as in previous demo.

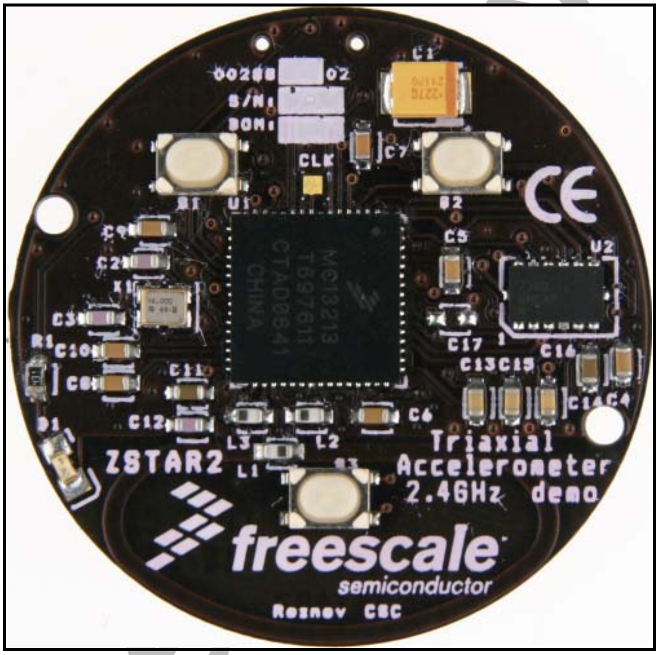


Figure 2-1. ZSTAR3 sensor board

The demo consists of the two boards(new one and old one with new software):

- Sensor Board (or remote board) it is new board designed to demonstrating Freescale new 3-axes accelerometers solution for digital(MMA7450L) and analogue(MMA7360L) sensing accelerometric data and 2.4GHz RF modem with HCS08 microcontroler in one packege solution as easy design for remote sensors.
- USB stick, with the MC13191 RF front-end, and the HC08 family MCHC908JW32 for the USB communication. This board are used from older ZSTAR demo with new software.

Both sides communicate over the RF medium utilizing the freely available software lightly modified stack SMAC from Freescale.

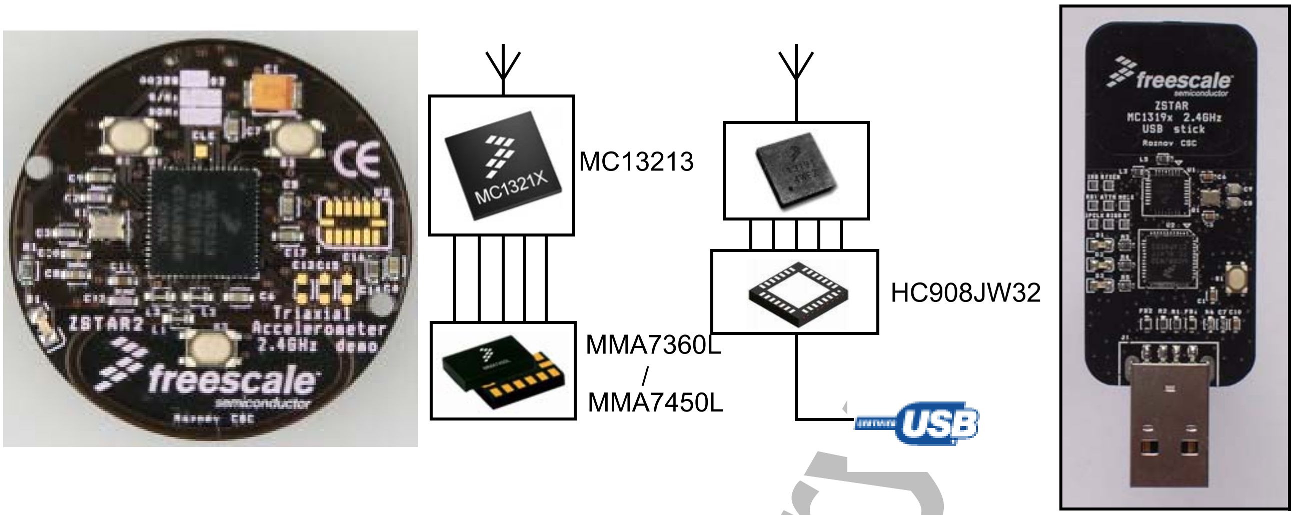


Figure 2-2. ZSTAR3 Block Diagram

2.2 Features of ZSTAR3

- Sensing of acceleration in 3 axes
- Handles digital and analogue sensors
- Wireless communication with sensors through the **2.4 GHz** band
- RF protocol supports **16** sensors on one USB stick (receiver)
- STAR topology of RF network
- Data rate of a sensor is **30**, **60** or **120 Hz**
- Typical wireless range is 20 m, two walls or one floor
- Auto calibration function of the sensor
- USB communication on the receiver part
  - — Virtual serial port - interface for GUI and serial port terminal
  - — HID class - mouse for windows
  - — HID class – keyboard (game controller)
- 8-bit/16-bit working modes
- 3 push buttons on the sensor board
- Current consumption:
  - — in normal run mode: 1.8 - 3.9 mA, depends on the actual data rate
  - — in sleep mode: less than 900 nA
- Power consumption depends on the current output values of the sensor. At a standstill, the board transmits only every 10th packet
- Sensor Board is powered by a coin-sized CR2032 3V battery
- Small size board fits a circular plastic box

2.3 Featured Products

This demo consists of several Freescale products whose main features are listed below. There are come up two accelerometers, because the Sensor board can be assembled with digital or analogue Freescale accelerometer.

2.3.1 Triple Axis Analogue Accelerometer MMA7360L

The MMA7360L is a low power, low profile capacitive micromachined accelerometer featuring signal conditioning, a 1-pole low pass filter, temperature compensation, self test, 0g-detect which detects linear freefall, and g-Select which allows for the selection between 2 sensitivities. Zero-g offset and sensitivity are factory set and require no external devices. The MMA7360L includes a sleep mode that makes it ideal for handheld battery powered electronics.

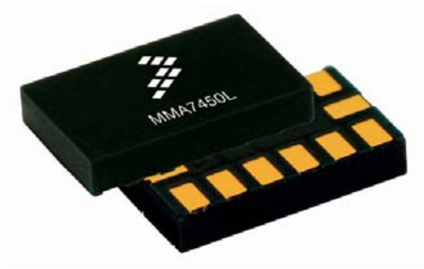
Features:

- 3mm x 5mm x 1.0mm LGA-14-pin package
- Low current consumption: 400 µA
- Sleep mode: 3 µA
- Low voltage operation: 2.2 V - 3.6 V
- High sensitivity (800 mV/g at 1.5g)
- Fast turn on time (0.5 ms enable response time)
- Self test for freefall detect diagnosis
- 0g-Detect for freefall protection
- Signal conditioning with low pass filter
- Robust design, high shocks survivability
- RoHS compliant
- Environmentally preferred product
- Low cost

2.3.2 Triple Axis Digital Accelerometer MMA7450L

The MMA7450L is a digital output (I2C/SPI), low power, 3x5x0.8mm low profile package capacitive micromachined accelerometer featuring signal conditioning, a low pass filter, temperature compensation, self test, configurable to detect 0g through interrupt pins (INT1 or INT2), and pulse (click) detect for quick motion detection. The 0g offset can be customer calibrated using assigned 0g registers and g-Select which allows for command selection for 3 sensitivities (2g/4g/8g). Zero-g offset and sensitivity are factory set and require no external devices. The MMA7450L includes a standby mode that makes it ideal for handheld battery powered electronics.

Features:



- Digital output (I2C/SPI) for processor system performance
- Low-profile 14-pin 3mm x 5mm x 0.8mm LGA package
- LGA volume is 77 percent smaller than Quad Flat No-Lead (QFN) package
- XYZ: three axes of sensitivity in one device (2g, 4g, 8g)
- Low current consumption: 400 µA
- Standby mode: 5 µA
- Low-voltage operation: 2.4 V - 3.6 V
- Customer assigned registers for offset calibration
- Programmable threshold interrupt output
- Level detection for motion recognition (shock, vibration, freefall)
- Single or double click (pulse) recognition
- High sensitivity
  - — 64 LSB/g at 2g
  - — 64 LSB/g at 8g in 10-bit mode

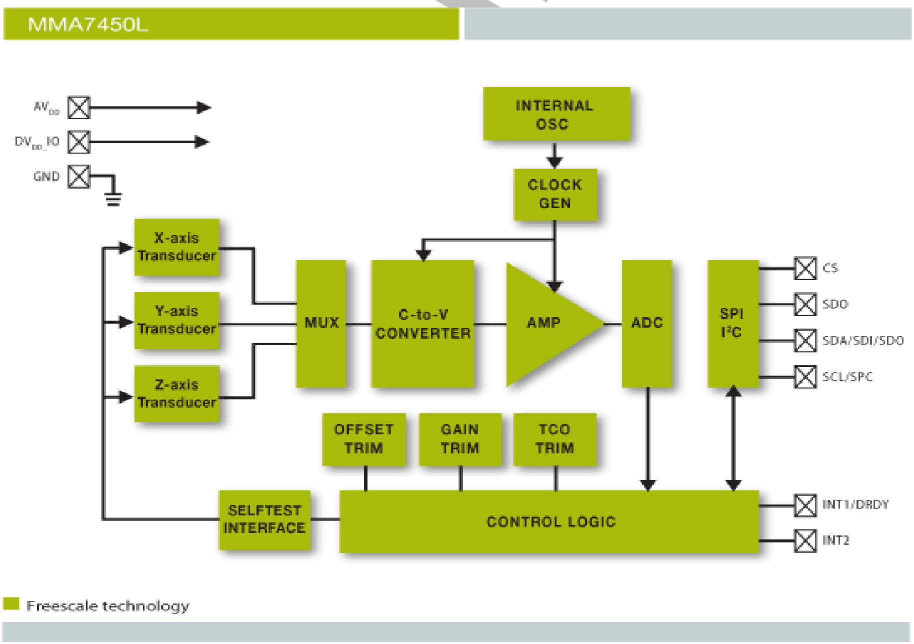


Figure 2-3. Block diagram of MMA7450L

2.3.3 The SiP(System in Package) MC13213

The MC13213 System in Package (SiP) integrates the MC9S08GT MCU with the MC1320x transceiver into a single 9x9mm LGA package. The MC13213 provides 60 K Flash memory and 4 K of RAM. By using the IEEE 802.15.4 Compliant MAC, or BeeStack ZigBee Protocol Stack, the MC13213 is an ideal solution for sensing and control applications that require mesh networking.

Features:

- 40 MHz HCS08 low-voltage, low-power core
- 60 KB Flash and 4KB RAM memory
- Seven addressing modes for CPU
- Multiple 16-bit timers
- 2V to 3.4V operating voltage with on chip voltage regulator
- -40 to +85 degrees C operating temperature
- Low external component count
- Requires a single 16 MHz crystal
- Programmable frequency clock output for MCU
- Auto-trim feature for crystal accuracy
- Eliminate need for external variable capacitors
- Allows for automated production frequency calibration
- 9x9x1 mm 71-pin LGA package
- RoHS compliant
- Up to 38 GPIO
- 8-bit port keyboard interrupt (KBI)
- 8-channel 10-bit analog-to-digital converter (ADC)
- Two independent serial communication interfaces (SCI) supporting up to 115.2 kBaud
- Inter-integrated circuit (I2C) with 100 kbps maximum bus loading
- Internal clock generator (ICG) at 100 kHz or 16 MHz (including internal reference generator)
- Low-voltage detection
- In-circuit debug and Flash programming available via on-chip background debug module (BDM)
- Programmable low voltage interrupt (LVI)
- Common on-chip processor (COP) watchdog timer
- Operates in the 2.4GHz band
- 250 kbps O-PQSK modulation
- 16 selectable channels
- 0 dBm nominal output power
- Programmable from -27 dBm to +3 dBm
- Receive sensitivity of -92 dBm (typical) at 1% PER
- Integrated transmit/receive switch

- Supports single-ended or full differential operation
- Supports external low-noise amplifier (LNA) and/or Power Amplifer (PA)
- Three lower power modes for increased power life
- Supports streaming and data processing modes

Software features:

- Simple MAC
  - Small memory footprint (< 4 KB)
  - Supports point-to-point and star network configurations
  - ANSI C source code
- IEEE 802.15.4 compliant MAC
  - Supports star, mesh and cluster tree topologies
  - Supports beaconed and non-beaconed networks
  - Supports guaranteed time slots (GTS) for predicable latency
  - 128-bit Asymmetric Encryption Standard (AES)
  - Object Code
- BeeStack ZigBee Protocol Stack
  - ZigBee 2006 Complian Platform
  - Object Code

Chapter 3
ZSTAR3 Sensor Board Description

3.1 Board Overview

The Sensor Board utilizes a small footprint size dual-layer printed circuit board (PCB) containing all the necessary circuitry for both accelerometer sensors and transferring data over a radio frequency (RF).

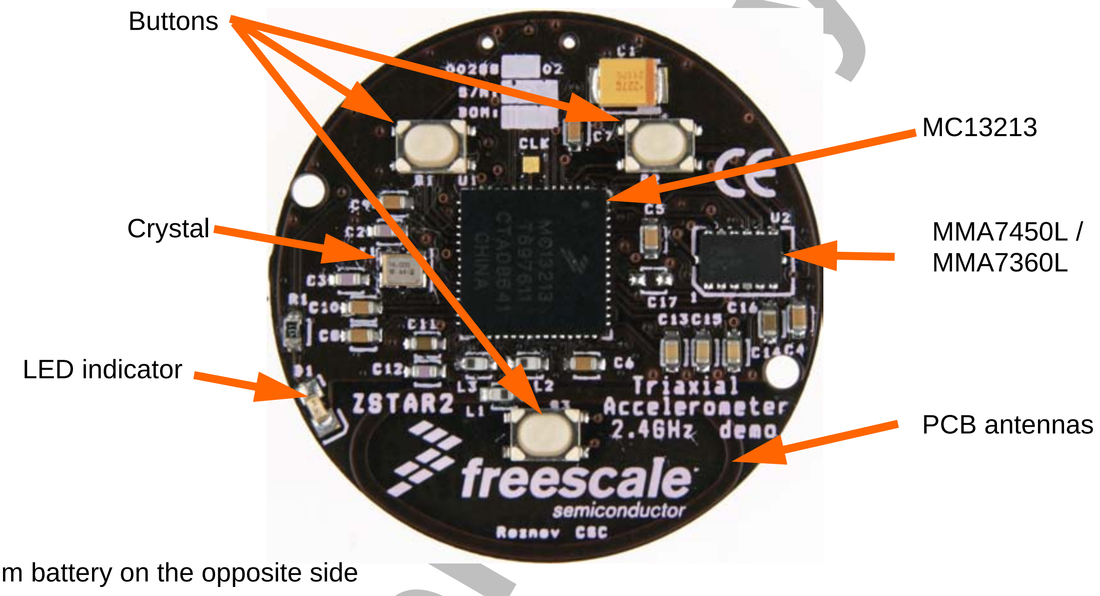


Figure 3-1. ZSTAR3 Sensor Board Overview

The board is powered by a Lithium coin-sized CR2032 battery. The block diagram of the board is as follows:

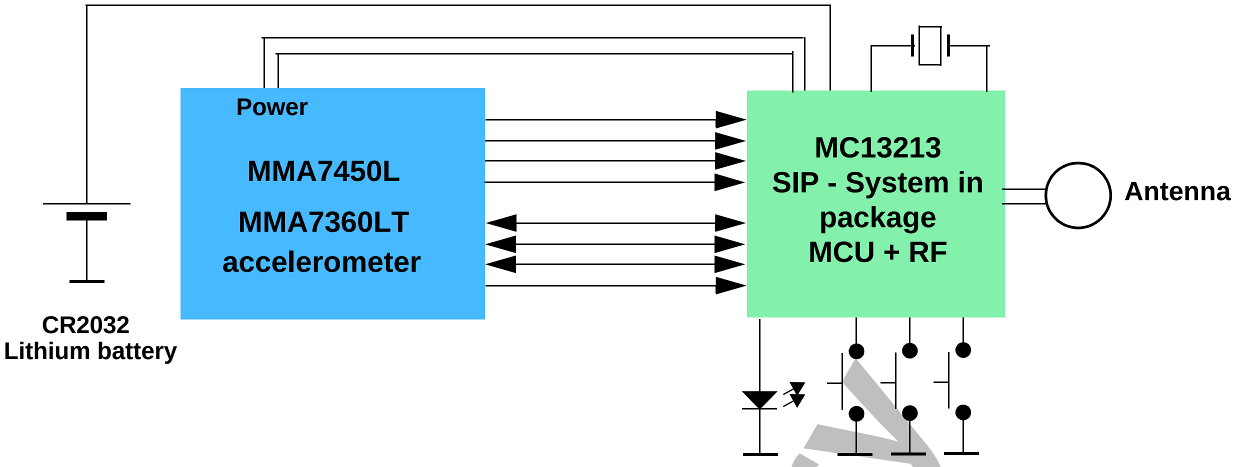


Figure 3-2. Sensor Board Block Diagram

Figure 3-3. - ZSTAR3 Sensor Board Software Overview shows in more detail, how different software and hardware modules co-operate with each other. The main task of the Sensor Board is to:

- periodically wake-up from power saving mode
- measure all three XYZ acceleration values from the Sensor
- compose a data frame using simple ZSTAR3 RF Protocol
- use SMAC (Simple Media Access Controller) to send this data frame over the RF link
- go to sleep

This basic loop repeats roughly 30 times per second (period is 33.333ms) providing nearly a real-time response from the Sensor.

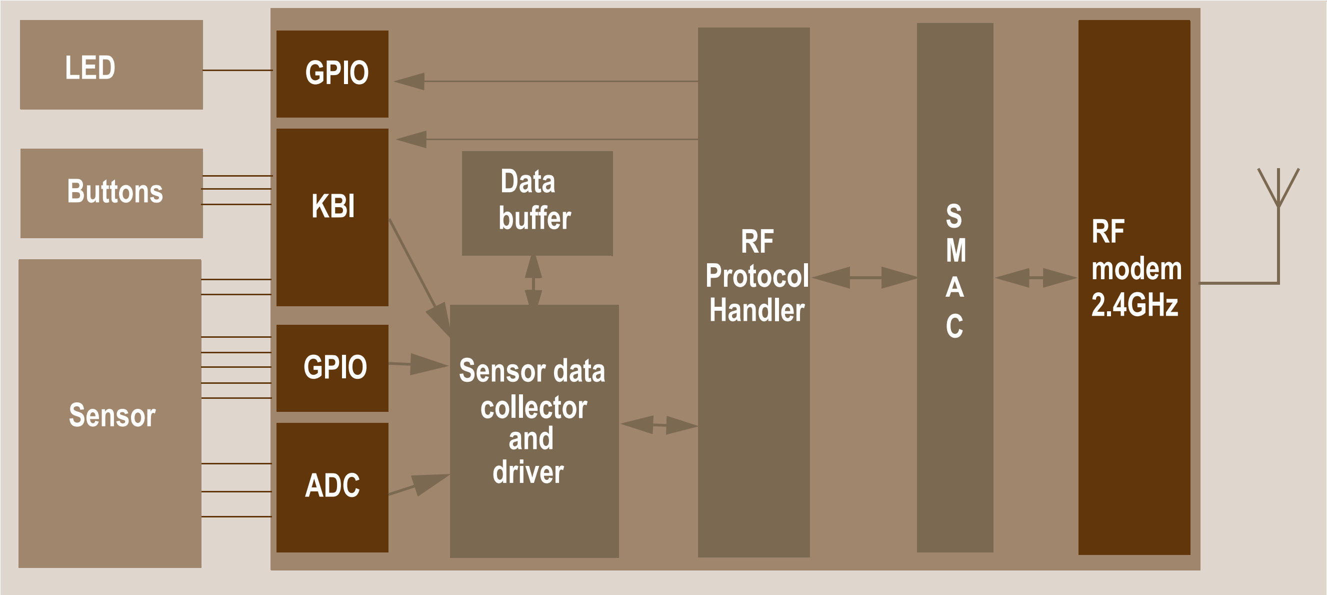


Figure 3-3. ZSTAR3 Sensor Board Software Overview

For the Sensor Board operation, several of the MC13213’s hardware modules are used: Analog to Digital Converter (ADC), Synchronous Peripheral Interface (SPI), External Interrupt Request (IRQ), Keyboard Interrupts and General Purpose Input/Output (GPIO).

3.2 Accelerometric sensor sw controller

Reading of XYZ levels and all others operation with sensor is depends on current assembled sensor. The ZSTAR3 sensor board supports two types of Freescale accelerometric sensors, analogue(MMA736xLT) and digital(MMA745xL). Assembly sensor is powered by IO pins of MCU, this solution allow reach a lowest power consumtion in sleep mode.

3.2.1 Double sensor support software model

All common control functions of sensor are physically create as two individual function. First for analogue and second for digital sensor. Main software is using only volatile pointers on this function, that are assigned within initialization of program, by ” `Recognise_Sensor()` “ function. This function recognises an assembled sensor and assigns right functions address to volatile RAM pointers. For example, by this way analogue sensor is using ADC to read XYZ values of sensor and digital sensor is using digital interface, but in source code are only one line:

```
p_Read_Accelerometer((void*) &(accel_data[0].x)).
```

3.2.2 Autocalibration process

The software uses for both types of sensor autocalibration process to get offset calibration values. It uses a simple 0g X, 0g Y, +1g Z acceleration method. The sensor board runs autocalibration process for each g scale of sensor, and thus uses for each g scale induvidual set of calibration values. For more details see application note AN3447 - Implementing Auto-Zero Calibration Techniquefor accelerometers on www.freescale.com.

3.2.3 Analogue sensor software support

The 3-axis accelerometer Sensor MMA7360L provides three separate analog levels for the X, Y and Z axis. These outputs are ratiometric which means that the output offset voltage and sensitivity will scale linearly with applied supply voltage. This is a key feature when interfacing to a microcontroller with A/D converter reference levels tied to a power supply, because it provides system level cancellation of supply induced errors in the analog to digital conversion process.

During the analog-to-digital conversion in the microcontroller, 10-bit resolution is used. MC13213 A/D channels 0, 1 and 2 are connected to X (channel 1), Y (channel 2) and Z (channel 0) outputs of the MMA7360L. The microcontroller’s `APCTL1` register enables these ADC channels for pin I/O control by the ADC module.

The `ADCCFG` register controls the selected mode of operation, clock source, clock divide, and configuration for low power or long sample time.

The MMA7360L sensor has implemeted digital output of freefall detection module. This output is connected direct to KBI(Keyboard interrupt module) and it’s used as default source of freefall detection.

3.2.4 Digital sensor software support

The MMA7450L provides a lots of various features, that almost are using by the ZSTAR3 demo. Complete communication with sensor is done by digital interface. MMA7450L supports two standards of digital comunication: SPI(Serial Peripherial Interface) and IIC(Inter-Integrated Circuit).

3.2.5 Power Management

A CR2032 Lithium battery provides a fairly limited charge for such a realtime-like demo that demands frequent transmissions. Some sort of power management has to be implemented in order to keep the current consumption at a reasonable level.

Typically, current consumptions of Sensor Board components are as follows:

- SIP - System in Pack MC13213
  - 2.4GHz transceiver of MC13213
    - in Off mode, 200nA
    - in Hibernate mode, 2.3µA
    - in Doze mode, 35µA
    - in Idle mode, 500µA
    - in Transmit mode, 30mA
    - in Receive mode, 37mA
  - 8-bit microcontroller of MC13213

    - in Stop3 mode, 700nA
    - in Wait mode, 560µA
    - in Run mode, 6.5mA
- Triaxial accelerometers
  - low-g triaxial analogue Sensor MMA7360L
    - in Sleep mode, 3µA
    - in Normal mode, 400µA
  - low-g triaxial digital Sensor MMA7450L
    - in Sleep mode, 5µA
    - in Normal mode, 400µA

It is obvious that in a battery operated application care must be taken to ensure the lowest possible current consumption, especially when the maximum current (provided by the battery) is somehow limited. A CR2032 Lithium battery cannot provide current in the range of 40mA for long periods of time. To alleviate high current surges, an additional large capacitor has been designed.

For transmission and reception using the MC13191, a specific scheme has been used to ensure the battery is not depleted or overloaded. Targeting a 30 samples per second (33ms period) transmission rate. For better power managment software using system of skiping transmission if sensor data are same or very similar as in previous trasmit sample. Maximum count of skip trasmission is 10, then sensor data are always transmitted and by this way is clear Timout timer in USB Stick. The ZSTAR3 typically open receive window each 10th period (~333ms) to keep synchronization with USB Stick (Communication Master) and for receive possible control data from master.

The following scheme for one transmission/sleep cycle is used for the typically data transfer:

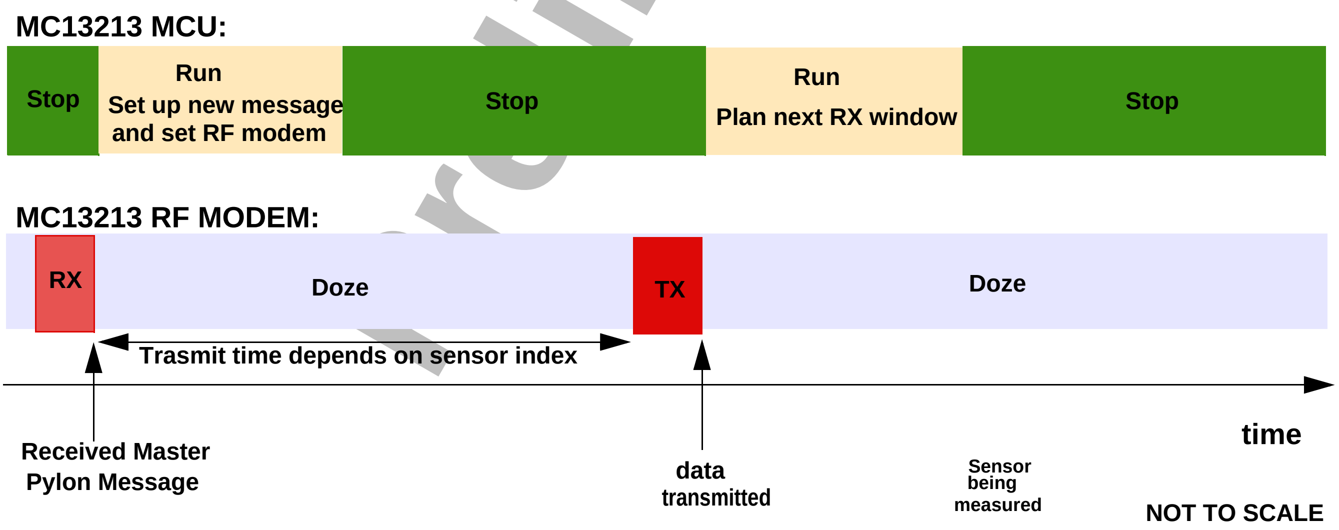


Figure 3-4. Transmission/Sleep Cycle Details by basic 30Hz datarate

As shown on the previous diagram, all parts of the Sensor Board remain most of the time in Sleep/Doze/Stop modes, in which the total current consumption is below 10µA.

The current consumption of the transmitter is ~30mA at that time, but only for a short period of time (typically ~600µs by 30Hz).

In order to keep the Sensor Board informed on the status of connection (for example, if the data-receiving side - USB stick - is out of range, disconnected, etc.) and still synchronize with master, the reception has to be turned on after the data has been transmitted. This is not really required within each loop cycle, and in the actual implementation only on every 8th loop the receive window opens (receiver is enabled to receive the acknowledgment). More in Section 5.3, “ZSTAR3 RF Protocol description.

The reception window is larger to fit any incoming receive data and the current consumption is also higher during reception, so this portion of current consumption would be one of the largest if the acknowledgment was received in every loop cycle.

The “optional receive” feature allows huge power savings, still keeping the reception of acknowledgment data from the data-receiving side.

Some further savings might be incorporated by utilizing the timer-triggered transceiver events that are described in the MC13213 Reference Manual.The MC13213, for example, latches a so-called time-stamp of each received frame. The data-receiving side read this value and trigger the acknowledgment sent at exactly specified time after reception (also, a start of data frame transmission can be programmed as timer-triggered). The Sensor Board then narrow its own receive window to perfectly match the expected time of the acknowledgment frame.

3.2.6 MC13213 Modem Power Management Features

MC13213 modem provides several power saving modes. One of them is called **Doze mode** in which the MC13213 modem crystal oscillator remains active. An internal timer comparator is functional too, providing a power efficient and accurately timed way of waking-up the application after a specified time.

This feature is fully utilized within the Sensor Board. The microcontroller calculates the time period for which the application should be in power saving mode, then fills in the timer comparator registers in the Modem, and the microcontroller goes into Stop mode (modem into Doze mode).

Once the timer reaches the pre-programmed time (a timer compare occurs), the modem’s IRQ signal is asserted which brings the microcontroller out of the Stop mode. There are various scaling possibilities that allow periods from a few µs up to 1073 seconds (~17 minutes) to be programmed, without intervention of the microcontroller.

3.3 ZSTAR Sensor Board Hardware Overview

This section describes the Sensor Board in terms of hardware design. The MC13213 SIP drives only the analogue or digital triaxial sensor. Because for analogue and digital sensor is used only one footprint, thus has to be connected all necassary pins for both sensors and these connection has to be logical fit for both sensors.

3.3.1 Sensors power supply

Sensor are powered by IO pins of microcontroler. This can be done, because sensors consumed less than 0.5mA Three output pins together are used for analog VDD supply pin of sensor. This option hold down dynamically changes of voltage with different current consumption of sensor.

Main feature of this solution is unbeatable currunt when complete board is in deep sleep mode (all board concum less than 1µA). Thus by this option the ZSTAR3 hasn't to using sleep modes of sensors.ore details in section 3.3.1/3-Sensors power supply-21

3.3.2 Analogue sensor connection

The MMA7360L Sensor outputs are connected to AD0, AD1, and AD2 inputs to analog-to-digital converter via RC filters formed by internal resistors in sensor and C13, C14, C15. These are recommended to minimize clock noise from the switched capacitor filter circuit inside the Sensor. Once the software filtering (also described in) is employed, these RC filters may be completely omitted.

The MMA7360L provides four next digital signals **g-select**, **Self-test**, **0g-detect** and **Sleep**. All these pins are also routed to microcontroler, but only g-select and 0g-detect are use by software.

3.3.3 Digital sensor connection

The MMA7450L sensor are control by digital interface and two interrupts pins. Digital interface take a 4 wires, that provides both interfaces - IIC and SPI. These pins are routed to general IO pins and IIC microcontroler module, but board doesn't provide external pull up resistors and thus can't be used IIC module. This option saving a energy of battery in deep sleep mode.

- **pin 13 - SDA/SDO/SDI** - IIC data, SPI data input/output
- **pin 12 - SDO** - SPI data output
- **pin 14 - SCL/SPC** - IIC clock, SPI clock
- **pin 7 - CS** - Chip select

Two interrupts pin called INT1/DRDY and INT2 are routed direct to KBI module of microcontroler. By this option software can be build on interrupts events. Signals use internal pull up resistors in microcontroler.

- **pin 8 - INT1/DRDY** - interrupt 1 output, Data Ready output
- **pin 2 - INT**2 - interrupt 2 output

When is digital sensor connected, then on footprints C13, C14 are placed 0R resistors. These two resistors grounded pin2 and pin4 of digital sensor.

3.3.4 BDM (Background Debug Mode) Connections

A J2 connector is a non-standard footprint primarily intended for in-factory programming and testing via "spring-needle" type of connections. The J2 connector carries all standard signals for Background Debug Mode communication so if required, one may solder wires and a standard 2x3 pins 2.54mm (100mil) pitch header for regular BDM re-programming. The pin numbering is shown on Figure 3-5. - BDM Connector Layout

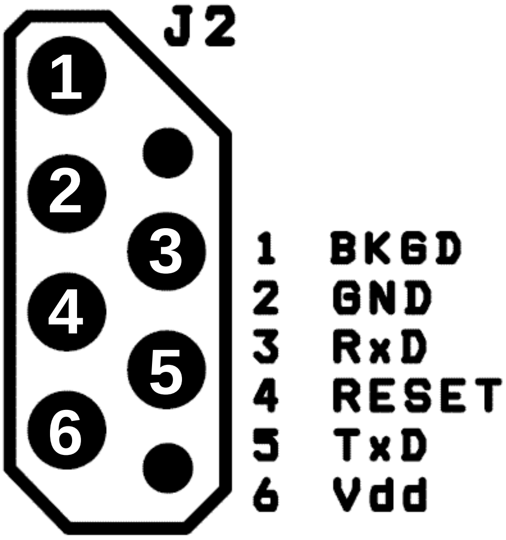


Figure 3-5. BDM Connector Layout

3.3.5 Button Connections

Three buttons (S1, S2 and S3) are connected directly to pins PTA0, PTA6 and PTA7. All have internal pull-up resistors, and are part of the Keyboard Interrupt module, therefore allow a direct microcontroller wake-up from the Stop modes.

3.3.6 MC13213 RF Interface

The RF interface (antennas) were designed with the cost and board size in mind. Among several designs, the PCB layout antennas were in the main consideration (cost). Of several PCB antenna designs available for the 2.4GHz band (F-antenna, dipole, loop), the loop antenna has been selected mainly because of the size required on the PCB.

The MC13213 transceiver provides a internal antenna switch of RF IN (receive) and PA OUT (transmit) paths, thus can be use a simple loop antenna.

The antenna is designed as a “smile” layout , 10.7x24.3mm (420x960mils), made of 1.25mm (50mils) wide trace of copper.

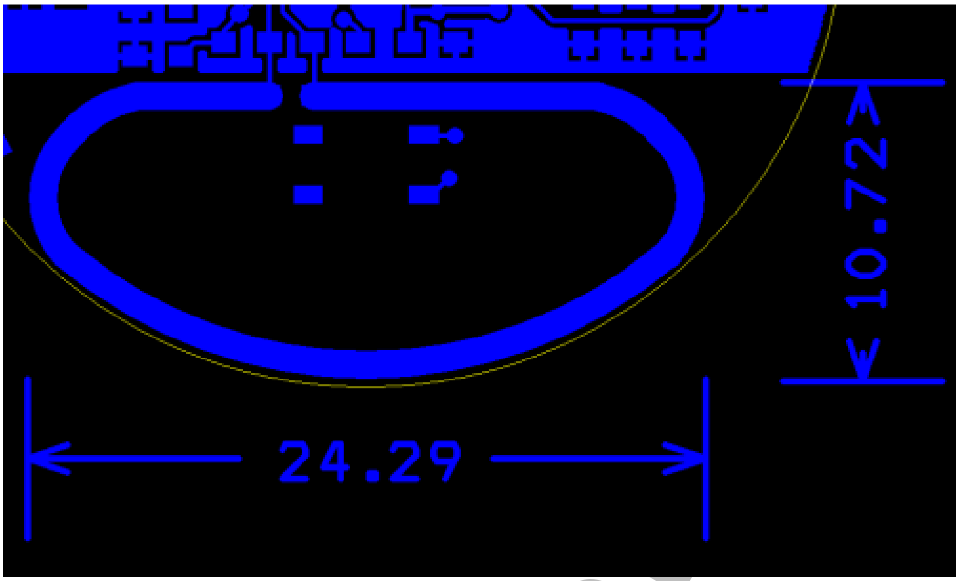


Figure 3-6. ZSTAR3 Antenna Layout

The matching is provided by L1 coil. L2 and L3 coils bias the transmitter output transistors to the CT_Bias level.

The inductors used in this design are from TDK:

- L1 (3.3nH) MLG1608B3N3DT
- L2, L3 (22nH) MLG1608B22NJT

3.3.7 Clocking Options of MC9S08QG8

Due to the availability of accurate timing provided by the MC13213 internal transceiver, an internal oscillator (ICG) in the MC13213 microcontroler is used as the main clock source for the microcontroller. The protocol related timing is derived from RF modem timers, the microcontroller itself is clocked from an internal oscillator. Microcontroler clock run with 20MHz on bus.

3.3.8 LED Indicator

On the design is used only a one LED, because the ZSTAR3 board is designed to fit a plastic box, that has only a one position for light indicators. The LED is connected with current limiting serial resistor R1 direct to PTC5 microcontroler pin.

3.3.9 Power Supply

The Sensor Board is powered by a Lithium coin-sized battery. The primary choice was the popular CR2032.

A surface mounted SMTU series battery holder from Renata^{TM} is placed on the underside of the PCB. The SMTU series holders provide (by mechanical construction) battery reverse protection, so no additional circuitry is required.

A large tantalum capacitor (C1, 220µF/4V) improves the response of the power supply to current peaks caused by reception or transmission. Coin-sized Lithium CR2032 batteries are targeted at a maximum continuous discharge current in the range of 3mA. Such a large capacitor helps to supply enough current to the MC13213 during a receive/transmit without significant V_{dd} voltage drops.

Design doesn’t have any main power switch, thus switch on is done by pressing any button on board and switch off is done by software (Timeout, Out of range, RF protocol command).

3.4 Bill of Materials

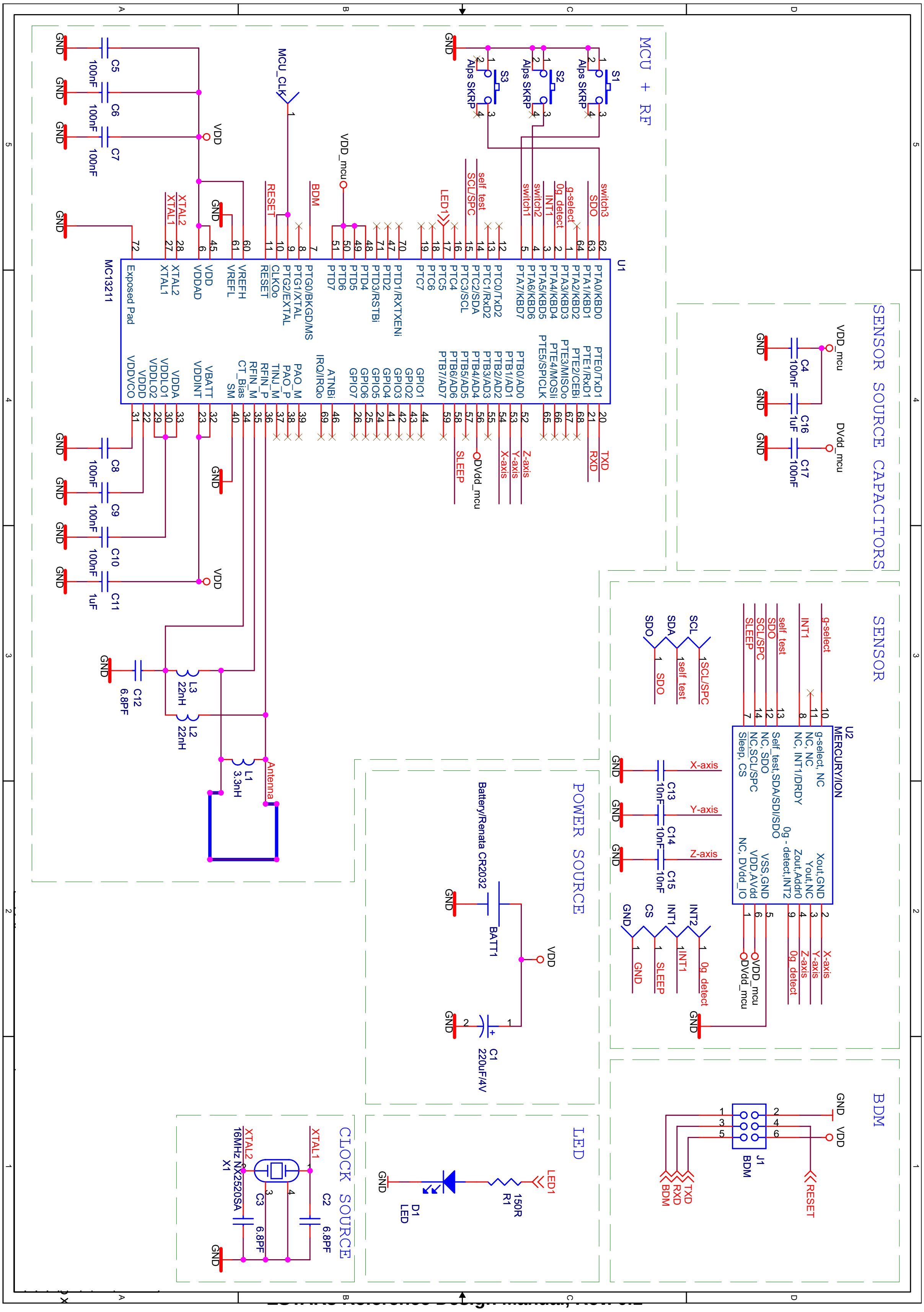
Table 3-1. Sensor Board Bill of Materials - Analog Sensor version

Item	Quantity	Reference	Part	Manufacturer	Manufacturer order code
1	1	BATT1	battery holder CR2032	Renata	SMTU 2032-1
2	1	C1	220uF/4V	AVX	TAJB227M004R
3	3	C2, C3, C12	6.8pF	TDK	C1608CH1H070D
4	7	C4, C5, C6, C7, C8, C9, C10	100nF	TDK	C1608JB1H104K
5	2	C11, C16	1uF	TDK	C1608JB1A105KB
6	3	C13, C14, C15	10nF	TDK	C1608CH1E103J
7	1	L1	3.3nH	TDK	MLG1608B3N3DT
8	2	L2, L3	22nH	TDK	MLG1608B22NJT
9	1	D1	Kingbright KP-1608SEC	Kingbright	KP-1608SEC
10	1	J1	BDM + serial	N/A	
11	1	X1	16MHz NX2520SA	NDK	NX2520SA 16MHz EXS00A-02940 Specification n° EXS10B-07228
12	1	R1	150R	TYCO	RN73F1J150RBTG
13	3	S1, S2, S3	switch SKRP	Alps	SKRPADE010 (or SKRPACE010 or SKRPABE010)
14	1	U1	MC13213	Freescale	MC13213
15	1	U2	MMA7360LT	Freescale	MMA7360LT
16	1	C17	NA	NA	NA

Table 3-2. Sensor Board Bill of Materials - Digital Sensor version

Item	Quantity	Reference	Part	Manufacturer	Manufacturer order code
1	1	BATT1	battery holder CR2032	Renata	SMTU 2032-1
2	1	C1	220uF/4V	AVX	TAJB227M004R
3	3	C2, C3, C12	6.8pF	TDK	C1608CH1H070D
4	8	C4, C5, C6, C7, C8, C9, C10, C17	100nF	TDK	C1608JB1H104K
5	2	C11, C16	1uF	TDK	C1608JB1A105KB
6	3	C13, C15	**0R**	PHYCOMP	232270296001
7	1	L1	3.3nH	TDK	MLG1608B3N3DT
8	2	L2, L3	22nH	TDK	MLG1608B22NJT
9	1	D1	Kingbright KP-1608SEC	Kingbright	KP-1608SEC
10	1	J1	BDM + serial	N/A	
11	1	X1	16MHz NX2520SA	NDK	NX2520SA 16MHz EXS00A-02940 Specification n° EXS10B-07228
12	1	R1	150R	TYCO	RN73F1J150RBTG
13	3	S1, S2, S3	switch SKRP	Alps	SKRPADE010 (or SKRPACE010 or SKRPABE010)
14	1	U1	MC13213	Freescale	MC13213
15	1	U2	MMA7450L	Freescale	MMA7450L
16	1	C14	NA	NA	NA

3.5 ZSTAR3 schematic



Chapter 4
USB stick Board Description

4.1 Board Overview

The USB Stick board is used same as in original ZSTAR demo with new software. For more hardware details please check RD3152MMA7260 Reference Design manual on www.freescale.com

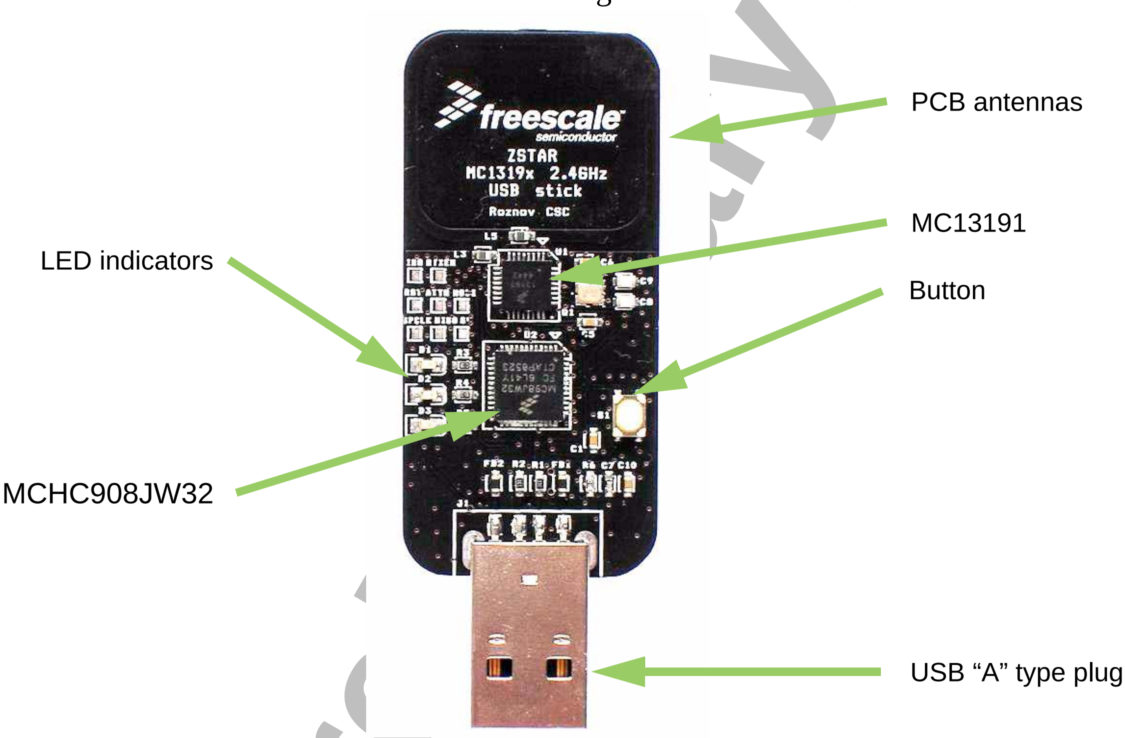


Figure 4-1. USB stick Board Overview

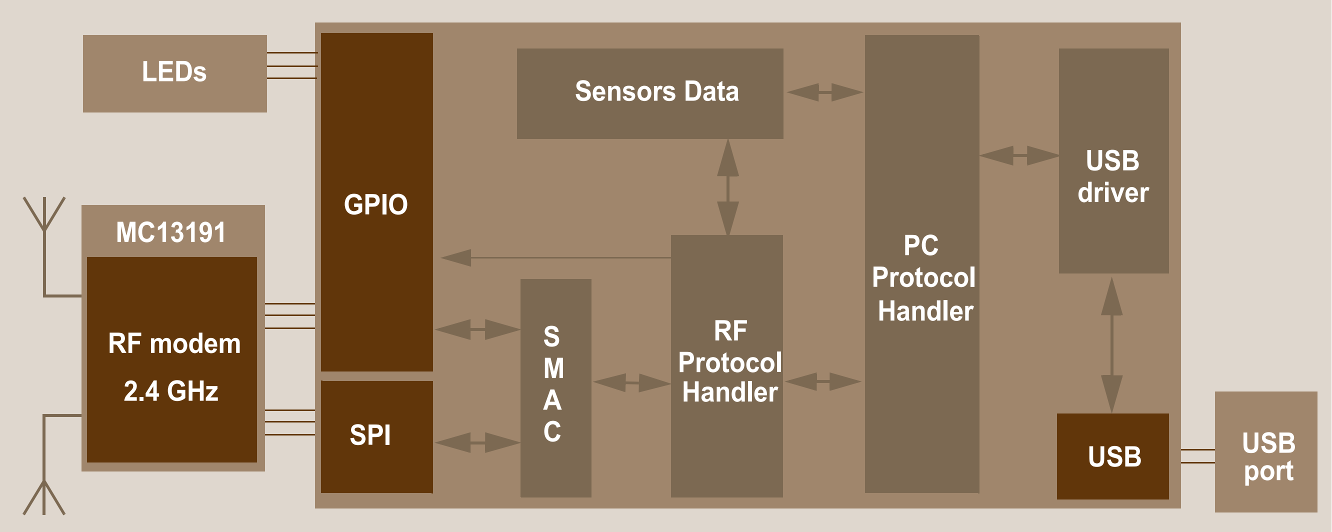


Figure 4-2. USB Stick software overview

Figure 4-2. USB Stick software overview shows, in more detail, how different software and hardware modules co-operate with each other. There are two main tasks of the USB stick board:

- receive the data from the MC13191 transceiver and store it in RAM buffer
- handle the USB module communication, decode and provide the data from the RAM buffer

These two are somewhat independent and the only common point between them is the accelerometer and button data buffer in RAM. The RF software communicates with the Sensor Board and retrieves the latest accelerometer data. This is stored in RAM and can be independently read by the PC application via the USB link. The protocol employed on the PC side is just a subset of the Original ZSTAR that is build on simple STAR protocol used in the original RD3112MMA7260Q demo. The protocol is described in section Section 5.4, “ZSTAR3 USB protocol - Extended STAR protocol.

For the USB stick board operation, several MCHC908JW32 hardware modules are used: USB 2.0 Full-speed (USB), Synchronous Peripheral Interface (SPI), Keyboard Interrupt (KBI) and a General Purpose Input/Output (GPIO).

Chapter 5
Software Design

5.1 Introduction

This section describes the design of the ZSTAR3 software blocks. The software description comprises these topics:

- 5.2, “SMAC (Simple Media Access Controller) modifications description
- ‘Air’ 5.3, “ZSTAR3 RF Protocol protocol description
- Serial 5.4, “ZSTAR3 USB protocol - Extended STAR protocol description
- AN2295 5.6, “Bootloader (over USB) implementation notes

5.2 SMAC (Simple Media Access Controller)

The SMAC is a simple ANSI C based code stack available as sample source code which can be used to develop proprietary RF transceiver applications using the MC1319x, MC1321x.

5.2.1 SMAC Features

- Compact footprint:
  - 2K FLASH
  - 10 bytes (+ maximum packet length) RAM
  - As low as 16kHz bus clock
- Can be used to demonstrate coin cell operation for a remote control
- MC1319x/MC1321x compatible
- Very-low power, proprietary, bi-directional RF communication link
- ANSI C source code targeted at the HCS08 core and portable to almost any CPU core (including 4-bit)
- Low priority IRQ
- Sample application included, extremely easy to use
- Liberally commented

5.2.2 Modifications of SMAC for ZSTAR3 RF protocol

The development of the ZSTAR software is based on the free SMAC stack available from Freescale. The SMAC version used was 4.2. To SMAC has been added a three new targets files for Original USB Stick / Sensor and for new ZSTAR3 sensor board. Furthermore was add a couple of new function to this SMAC.

A fully detailed description of the SMAC is in the SMAC Reference Manual (SMACRM.pdf), available together with SMAC source code.

5.2.2.1 New targets add to SMAC

Modification of SMAC for individual application are done by targets files that exact defines all pins and peripheries. For ZSTAR3 project purposes has been added to SMAC three new targets:

- MC1319XZSTAR_USB.c/h - these files describes Original ZSTAR USB Stick board
- ZSTAR_SENSOR.c/h - these files describes Original ZSTAR and ZSTAR3 Sensor board
- MC1321XZSTAR2.c/h - these files describes ZSTAR3 Sensor board

5.2.2.2 New functions add to SMAC

Original SMAC doesn't has implemented any advanced transceiver time operations as for example delayed trasmit / receive and others. On these functionalities is based ZSTAR3 RF protocol and thus had to be implemented. List of new functions in SMAC mac layer:

- UINT32 MLMEGetActualTime(void) - function return actual value of free run main counter in modem
- UINT32 MLMEGetTimeStamp(void) - function return time value of last received message
- UINT32 MLMEComputeDelay(UINT32 u32StartTime, UINT32 u32Delay) - function compute new time with delay
- UINT8 MLMEDelayTransceiver(UINT32 u32Time, UINT32 u32TimeOut, tTxPacket *psPacket,tRxPacket *psRxPacket, UINT8 u8mode) - main new function. This function provides delayed transmit, received with timeout, doze modes and general time interrupt

5.3 ZSTAR3 RF Protocol

ZSTAR3 uses a simple time based protocol for an RF transfer of information between Sensor Boards and USB receiver. ZSTRA2 RF protocol use simple star topology of communication net with one master point (USB Stick) and slaves(Sensor Boards). Protocol provides time slots up to 16 sensors. Main data load contents acceleration (X, Y and Z axis) and basic status data. The protocol is built on top of modified 5.2, "SMAC (Simple Media Access Controller) drivers that are available for the MC1319x and MC1321x transceivers family. The protocol is bidirectional allowing the set up of independent connections for a many of ZSTAR3 demos together in one RF space.

All data is transferred in so-called Zpackets. This protocol is primarily targeted at simple demo purposes, allowing a fast transfer of the accelerometer data in short packets with minimum overheads and with minimum battery loads (most of the receive windows eliminated, short transmit packets, etc.).

5.3.1 ZSTAR3 RF protocol features

- Based on modified Freescale SMAC library
- Star network topology
- One coordinator of network (master)

- Support up to 16 sensors (slaves)
- Network datarate is 30Hz (33.333ms)
- Data capture designed network
- Lock Network number (NetNum)
- Automatic/Manual select of communication channel
- Collect all RSSI(Receive Signal Strength Indicator) information of communication

5.3.2 Zpacket Format

The ZSTAR Zpacket is contained inside the MC1319x/MC1321x standard packet structure, which is consistent with the IEEE 802.15.4 Standard. The SMAC library transparently adds a 16 bit Packet control field (see chapter 7.2.1.1 of IEEE 802.15.4 Standard specifications) to differentiate packets from ZigBee and other standards.

The Zpacket becomes a payload data for the SMAC standard packet and contains the following fields:

- 5.3.2.1, "Network Number(NetNum)
- 5.3.2.2, "RX Strength
- 5.3.2.3, "Zcommand
- 5.3.2.4, "Zdata

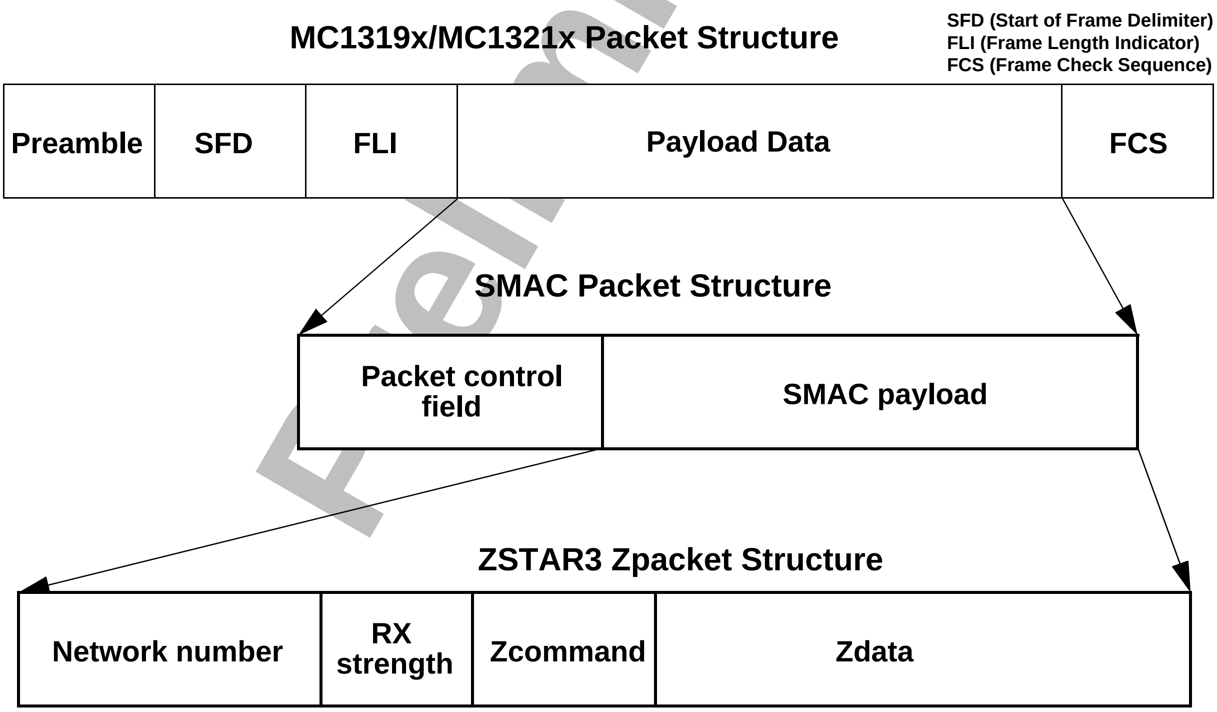


Figure 5-1. Zpacket Format

5.3.2.1 Network Number(NetNum)

The network number is save in FLASH memory of each participant with ZSTAR3 RF protocol. The USB Stick randomly generated it at the first time of lifecycle and it can be changed by command from PC. The new Sensor board has this number erased from manufacture and it can to update it when it received first valid packet in ZSTAR3 RF protocol format. Network Number in sensor board can be cleared by pressed all buttons during wake up sequency of board or it can be changed by command from USB Stick. It is used to determine between various connections. Packets with different Network numbers are simply ignored.

This field is 16 bits long.

5.3.2.2 RX Strength

This field reports the strength of the last received packet on the other end of the connection. This value simply tells us how well the other side receives ‘our packets’. This can be used by transmission power management functions to change the transmission power if the other party receives packets with enough strength.

The values reported are retrieved using the `MLMELinkQuality()` SMAC primitive.

This field is 8 bits long.

5.3.2.3 Zcommand

The ZSTAR demo protocol uses a few simple commands to establish and maintain the data flow between the Sensor Board and USB stick.

The command is carried in 5.3.2.3, “Zcommand field and is 8 bits long. The commands are defined as listed in Table 5-1., “Original ZSTAR commands Zcommand List, Table 5-2., “ZSTAR3 main commands Zcommand List, Table 5-3., “ZSTAR3 subcommands Zcommand List.

Table 5-1. Original ZSTAR commands Zcommand List

ZCommand	ZCommand code	Direction	Zdata
ZSTAR_BROADCAST	‘b’ (0x62)	USB stick to Sensor Board	none
ZSTAR_ACK	‘a’ {0x61)	USB stick to Sensor Board	none
ZSTAR_CALIB	‘k’ (0x6B)	USB stick to Sensor Board	calibration data to Sensor Board
ZSTAR_STATUS	‘s’ (0x73)	USB stick to Sensor Board	g-range selection data to Sensor Board
ZSTAR_CONNECT	‘c’ (0x63)	Sensor Board to USB stick	calibration data from Sensor Board
ZSTAR_DATA	‘d’ (0x64)	Sensor Board to USB stick	accelerometer values, temperature and bandgap voltage, button levels, g-range selection

Table 5-2. ZSTAR3 main commands Zcommand List

ZCommand	ZCommand code	Direction	Zdata
ZSTAR3_PYLON	0xA0	USB stick to Sensor Board	Status and optional subcommand
ZSTAR3_DATA	0x50	Sensor Board to USB stick	Accelerometers values, status info
ZSTAR3_DATA	0x60	Sensor Board to USB stick	none
ZSTAR3_CONNECT	0x40	Both	Calibration data, board info
ZSTAR3_ION	0x70	Sensor Board to USB stick	Optional return read data from ION

Table 5-3. ZSTAR3 subcommands Zcommand List

ZCommand	ZCommand code	Direction	Zdata
ZSTAR3_GUI	‘g’ (0x67)	USB stick to Sensor Board	none
ZSTAR3_MODE	‘m’ {0x6D)	USB stick to Sensor Board	Set up data of new mode
ZSTAR3_OFF	‘o’ (0x6F)	USB stick to Sensor Board	none
ZSTAR3_GSEL	‘s’ (0x73)	USB stick to Sensor Board	g-range selection data to Sensor Board
ZSTAR3_DATARATE	‘d’ (0x64)	USB stick to Sensor Board	new datarate
ZSTAR3_FLAG	‘f’ (0x66)	USB stick to Sensor Board	none

5.3.2.4 Zdata

The 5.3.2.4, “Zdata field follows the 5.3.2.3, “Zcommand field and may be empty if the actual command doesn’t require any additional data. The data format is dependent on the 5.3.2.3, “Zcommand. A detailed description is in the next chapter.

5.3.3 Original ZSTAR Zcommand Description

For more detail description of original ZSTAR Zcommands check RD3152MMA7260Q reference design manual ZSTARRM Reference design manual - Original ZSTAR demo(RD3152MMA7260Q) RDM.

5.3.4 ZSTAR3 Protocol Zcommand Description

All commands with direction Sensor board to USB stick are replinish(lower 4 bits) by information of sensor index.

5.3.4.1 ZSTAR3_PYLON

This is main and practically single command of USB Stick. Command is used as a net synchronization message and it’s one way how to get data and other sub commands to individual sensor boards. This command is replinish in protocol with mode of operation information (8/16 bits communication).

Zdata bytes:	0	1	2	3	4...
	List of active sensors	Selected sensor	Subcommand	Data depends on sub commands	

Figure 5-2. ZSTAR3_PYLON Zdata format

5.3.4.2 ZSTAR3_DATA

With this command sensors sensding measured data into USB Stick. This most frequently sensor board RF command.

5.3.4.3 ZSTAR3_ACK

This command is sensor using to acknowledge success received USB Stick subcommand.

5.3.4.4 ZSTAR3_CONNECT

By this command sensor board sends calibration data to USB Stick. Command is also using to starts communication between Sensor board and USB stick.

5.3.4.5 ZSTAR3_ION

This command is specially designed to answer all special requirements of digital sensor device[1].

5.3.5 ZSTAR3 Protocol SubCommands Description

The group of subcommands relates to main USb Stick RF ZSTAR3_PYLON command. All these subcommands can be send only as axtension of ZSTAR3_PYLON. Subcommands are way how to get data and majority commands from USb Stick to individual sensors.

5.3.5.1 ZSTAR3_GUI

This commnad is designed only to clearing timeout[2] in sensor and thus keep sensor in run mode.Sensor board answer by ZSTAR3_DATA command.

[1] ZSTAR3 with assembled MMA7450L - ION.

[2] Each sensor Board without power switch has automatically switch off function when overflow 2 minutes timeout.

5.3.5.2 ZSTAR3_MODE

This command is using only with ION device mounted on Sensor Board. Command can swtich individual digital work modes on digital sensor.Sensor board answer by ZSTAR3_DATA command.

5.3.5.3 ZSTAR3_OFF

This command request switch off sensor. Is available only on Sensor Boards without power switch.

5.3.5.4 ZSTAR3_GSEL

This command is used as a request of change actual g select of sensor to new.Sensor board answer by ZSTAR3_DATA command.

5.3.5.5 ZSTAR3_DATARATE

This command is used as a request of change actual datarate of sensor to new.Sensor board answer by ZSTAR3_DATA command.

5.3.5.6 ZSTAR3_FLAG

This is special additional subcommand that is used only with initial ZSTAR_BROADCAST command to recognize a RF protocol type - Original ZSTAR RF or ZSTAR3 RF Protocol.

5.3.6 ZSTAR3 RF Protocol description

ZSTAR3 Rf portocol is based on star RF network topology. The USB Stick is a master of the network and Sensor boards are slaves. All network runs within time based RF protocol, thus each device of the ZSTAR3 RF network has own time in each period for transmit. Receive time it’s little different, all Sensor Boards opens receive window in some time and tries to catch synchronization/data transmition of master, but USB Stick (master) has opened receive window all time when RF Sensor Boards transmits.

The ZSTAR3 devices runs with simple state machine:

1. **Init state** - Devices initialize all neccesarry hardware peripherials and software drivers. After initialization is done, state machine jumps to Broadcast state.
2. **Broadcast state:** this is little bit outdated state that is keep in protocol only for compatibilities modes of ZSTAR3 protocol with original protocol devices.
   - **Master (USB Stick)** - the ZStar3 protocol needs only find out free channel for prepared RF network, but because the ZStar3 demo supports original ZStar RF protocol, then this state is important only for compatibility capatibilities of the ZSTAR3 demo.
   - **Slave (Sensor board)** - In this state the Sensor Board is looking for the ZSTAR3 communication. Ad when it’s found the RF communication with right NetNum number and its time position is free, jump to the Run State of RF protocol. If not jumps to the Sleep state.
3. **Compatibility state with original ZSTAR:**

- **Master (USB Stick)** - USB Stick of the ZSTAR3 supports original ZSTAR RF protocol and this state provide it. For ore details check Manual for original ZSTAR ZSTARRM Reference design manual - Original ZSTAR demo(RD3152MMA7260Q) RDM.
- **Slave (Sensor board)** - Sensor board software conteins this state and it can support of original ZSTAR too, but all boards are ordered with prohibited compatibility.

4. **ZSTAR3 Protocol run state:**
   - **Master (USB Stick)** - Master is periodically transmiting synchronization ZSTAR3_PYLON message and then receiving all incoming messages from the Sensor boards within same NetNum. In this state Master collect all neccessary information about connection status all Sensor Boards and other user payload.
   - **Slave (Sensor board)** - In this state slave is periodically opening window to receive Master synchronization mesage, measuring sensor data and tranmitting measured data with exact time offset to air(master).
5. **Sleep state:**
   - Master (USB Stick) - Doesn’t have this state.
   - Slave (Sensor board) - When the Sensor Board goes this state, then switch off all peripheries on board and inside of microcontroller and prepare all board to at least power consumption.

5.3.6.1 Typical one period of ZSTAR3 RF protocol

The ZSTAR3 RF protocol (in normal run mode) period starts by ZSTAR3_PYLON message from master. In ideal case all active slaves has opened receive window and catches incoming ZSTAR3_PYLON message from master. When sleves received this synchronization message, all in same time measure sensor output values and prepared future trasmition in unique time after ZSTAR3_PYLON message from master. This time is depend on index of each slave device. In the meantime the master prepared the new receive window and pens it before first prospektive message of Slave 0 and keeps opened this window until time for all 16 devices elapses. When the master catches any message from slaves, process it and immediatly open new receive window, if the last message wasn't from 16th Slave device..

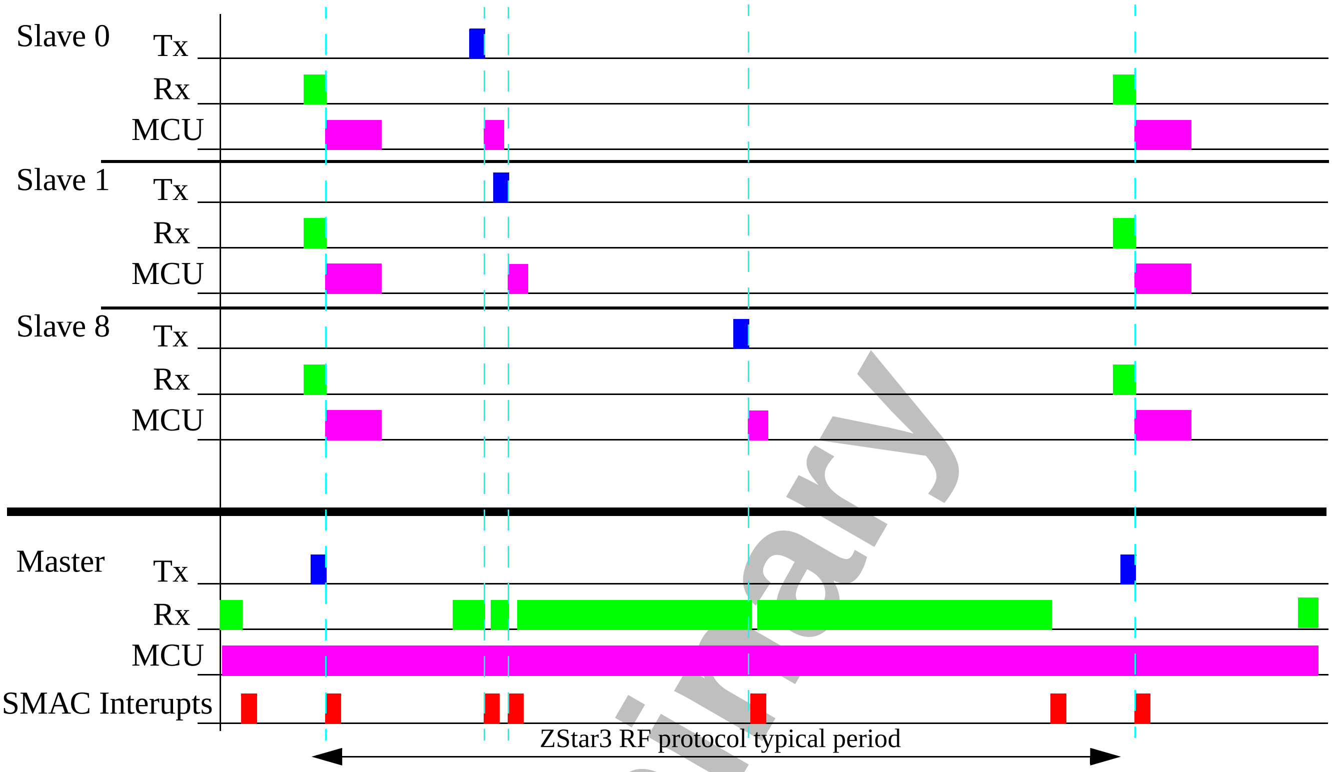


Figure 5-3. ZSTAR3 RF protocol period

5.4 ZSTAR3 USB protocol - Extended STAR protocol

The ZSTAR3 demo uses a subset of the original ZSTAR demo protocol commands.The Original ZSTAR is build on STAR demo protocol. This way, most of the software originally developed for the RD3152MMA7260Q (ZSTAR) and RD3112MMA7260Q (STAR) is also usable with the ZSTAR3.

The STAR demo communicates over the RS232 serial line with a simple text-based protocol. The same protocol is used in ZSTAR/ZSTAR3 for communication between the USB stick and a PC (over a virtual serial port). The PC application sees the same interface (serial port) and the same protocol as if a STAR demo was connected.

Because the ZSTAR3 can serve up to 16 connected sensor boards, all commands that works direct with sensor boards are communicated with one selected board by 'N' command from 5.4.3, "Subset of new added ZSTAR3 protocol commands.

5.4.1 Subset of original STAR protocol commands

The ZSTAR3 software contains all unchanged original STAR commands. Some commands can send extended information in ZSTAR3 mode - ZSTAR3 USB protocol extend some Original commands when PC send any command from new subset of command table. These extended information return to PC information of result individual commands.

Table 5-4. Original STAR commands

Normal Command			Extended Asynchronous Answer		Note
Command	Detail of command data	Length tx/rx (B)	Detail	Length rx (B)	
‘R’	‘N’	1, 1	-	-	Reset to 8 bit mode
‘V’	"x' value 'y' value 'z' value	1,6[1]	-	-	Read acceleration data
‘G’	g-select value	1, 1	-	-	g-select read
‘g’	g-select value, ‘G’, result	2, 0, 2	{'g',result,index}	7	g-select write
‘K’	"X' g(0) g(1) 'Y' g(0) g(1) 'Z' g(0) g(1)	1,. 9[2]	-	-	read calibration values[3]
‘k’	xg(0), xg(1), yg(0), yg(1), zg(0), zg(1), ‘K’, result	7[4], 0, 2	{'k',result,index}	7	write calibration values[5]

[1] Length of answer of measured data depends on actual work mode 8/16bits. 6 bytes for 8 bits, 9 bytes for 16 bits mode

[2] Length of answer of calibration values depends on actual work mode 8/16bits. 9 bytes for 8 bits, 15 bytes for 16 bits mode

[3] If is connected sensor with ZSTAR3 protocol, then this command return ideal constants of calibration

[4] Length of command calibration data depends on actual work mode 8/16bits. 7 bytes for 8 bits, 13 bytes for 16 bits mode

[5] If is connected sensor with ZSTAR3 protocol, then command calibration data isn’t important

Table 5-5. Legend of colors

Legend	
Red	Direction PC -> USB Stick
Blue	Direction USB Stick -> PC, regular data
Magenta	Direction USB Stick -> PC, extended data

5.4.2 Subset of original ZSTAR protocol commands

The ZSTAR3 software contains all lightly changed original ZSTAR commands.

Table 5-6. Original ZSTAR commands

Normal Command			Extended Asynchronous Answer		Note
Command	Detail of command data	Length tx/rx (B)	Detail	Length rx (B)	

Table 5-6. Original ZSTAR commands

‘r’	‘z’	1, 1	-	-	Reset to 16 bit mode
‘v’	'x' value 'y' value 'z' value 's' status 't' temperature 'b' bangap	1,17	-	-	Read extended 16 bits acceleration data[1]
‘I’	Text information about project	1, -	-	-	Return text information about ZSTAR project
‘U’	Debug information	1, -	-	-	Switch on sending useful debug information
‘u’		1,0	-	-	Switch off sending useful debug information
‘Q’	‘Q’	2, -	-	-	Debug autocalibration command
‘S’	Sensor RSSI, USB RSSI	1, 2	-	-	Read Receive Strength Signal Indicators

[1] ZSTAR3 RF protocol does not support bangap and temperature values, thus when USB Stick run with ZSTAR3 RF protocol this command always returning zeros in these fields

Legend of colors

Legend	
Red	Direction PC -> USB Stick
Blue	Direction USB Stick -> PC, regular data

5.4.3 Subset of new added ZSTAR3 protocol commands

The ZSTAR3 software contains all unchanged original STAR commands. Some commands can send extended information in ZSTAR3 mode - ZSTAR3 USB protocol extend some Original commands when PC send any command from new subset of command table. These extended information return to PC information of result individual commands.

Table 5-7. New ZSTAR3 commands (general commands)

Normal Command			Note
Command	Detail of command data	Length tx/rx (B)	
‘A’	‘a’, channel	1, 2	return actual select rf channel
‘a’	channel, ‘A’	2,1	set new RF channel, channel > 15 means automatically selection by USB Stick
‘B’	‘b’, Working State	1, 2	Get actual working state of ZSTAR
‘C’	‘c’	1, 1	Simply HandShake

Table 5-7. New ZSTAR3 commands (general commands)

‘H’	‘h’, netnum	1,. 3	Read Net ID number of RF communication
‘h’	netnum, ‘H’	3, 1	Set new Net ID number of RF communication
‘M’	datarate, ‘m’, result	2, 2	Set new datarate of sensor
‘m’	datarate	1, 1	Read actual datarate of sensor
‘N’	sensor index, ‘n’, result	2, 2	Change focus of communication to new sensor index
‘n’	sensor index, connected sensors mask	1, 3	Read index of focused sensor and mask of connected sensors
‘O’	'X' calibration offset 'Y' calibration offset 'Z' calibration offset	1, 6	Get true calibration offset values generated by autocalibration process
‘W’	sensor type,board type, sensor subtype, ZSTAR version	1, 5	Read information about type of board, sensor and USB Stick
‘X’	burst sensor mask, ‘x’, connected sensors mask	3, 3	Switch on burst mode of ZSTAR
‘x’	‘X’	1, 1	Switch off burst mode of ZSTAR
‘Z’	‘z’	1, 1	Go to Bootloader device

Table 5-8. New ZSTAR commands (Digital sensor part)

Normal Command			Extended Asynchronous Answer		Note
Command	Detail of command data	Length tx/rx (B)	Detail	Length rx (B)	
‘J’	address of reg, length of data, new values of reg 1-6 bytes, 'j', result	3-9, 2	{‘J’,result,index}	7	Direct access into ION registers, write
‘j’	address of reg, length of reading, 'J', result	3, 2	{‘j’,result,data 2 - 8 x2 Bytes}	9-23	Direct access into ION registers, read
L’	LDTH, SetByte, 'l', result	3, 2	{‘L’,result,index}	7	Level treshold detection switch on
‘l’	'L', result	1, 2	{‘l’,result,index}	7	Level treshold detection switch off
‘P’	PDTH, PW, LT, TW, Setbyte, ‘p’, result	6,2	{‘P’,result,index}	7	Pulse detection switch on
‘p’	'P', result	1, 2	{‘p’,result,index}	7	Pulse detection switch off
‘>’	Digital interface, ‘<‘, result	2, 2	{‘>’,result,index}	7	Change type of digital interface on communixcation with ION
‘<’	‘>’, Digital interface	1, 2	-	-	Read type of digital interface on communixcation with ION

Table 5-9. Legend of colors

Legend	
Red	Direction PC -> USB Stick
Blue	Direction USB Stick -> PC, regular data

5.4.4 Burst mode

A new mode of ZSTAR USB communication is burst mode. The Burst mode is designed to symplification reading process of new acceleration data. In burst mode USB Stick is sending all new received acceleration data from individual enabled sensor boards without any request command from PC.

Burst mode content:

- time of receive - 24bits time information with 4 us step
- manage byte - contain actual datarate, mode 8/16bits and index of Sensor board
- acceleration data + data status - this field can be multiply repeat up to 4 samples depends on actual datarate
- Status - contains information about select g range, buttons and events of last sample

Burst mode frame formats examples:

[ttttttmmxxyyzzddss] - 8 bits 30Hz frame

[ttttttmmxxxxyyyyzzzzddss] - 16 bits 30Hz frame

[ttttttmmxxxxyyyyzzzzddxxxxyyyyzzzzddxxxxyyyyzzzzddxxxxyyyyzzzzddss] - 16 bits 120Hz frame - worest case of communication

where is: t - receive time, m - manage byte, x- accelariotion in X axis, y- accelariotion in Y axis, z- accelariotion in Z axis, d - data status byte, s - frame status byte, [- start char and] is end char of frame.

Real example of burst mode frame:

”[BBBCDCA0D0001400400000D6002C00410000D9002D003D0000E1002F003D000020]”.

5.4.5 Network Lock feature of ZSTAR3 protocol

The ZStar3 RF protocol brings a new network lock function.This feature allow provide more ZSTAR3 networks in one RF space. For more details check section 5.3.2.1, “Network Number(NetNum).

5.4.6 Semiautomatic Self-Calibration

For the purpose of easier semiautomatic calibration of the ZSTAR demo with out PC GUI, the additional Calibration command ‘Q’ (0x51) has been added. This command is usually issued over terminal (e.g. HyperTerminal) software.

A user is required to place the Sensor Board into horizontal position(for example on a desk), in which the earth's gravity will induce a maximum acceleration in Z axis.First command 'Q' sent to USB Stick only prepare user to calibration by text help and second commnad 'Q' in line starts autocalibration process in Sensor board.

5.5 Compatiblity with Original ZSTAR

The new ZSTAR3 and new USB stick sw are fully compatible with original ZSTAR on USB communication, thus can be used all application designed for original ZSTAR as demo application RD3152MMA7260Q_SW. Compatibility was reach by keeping all original commands in communication protocol on USB.

USB Stick provides compatibility mode with original ZSTAR RF protocol. If first devices in brodcast mode is Sensor Board with original software, USB Stick is switched to Compatibility mode and start original ZSTAR RF protocol. When is Compatibility mode is active, any sensor can't be connect.

5.6 Bootloader

There's bootloader software implemented in MCHC908JW32 microcontroller. The bootloader is based on 1., "AN2295 Application note - Developer's Serial Bootloader for M68HC08 and HCS08 MCUs and AN2295SW related software. The original AN2295 bootloader targets serial connections between the PC and applications, and since the MCHC908JW32 implements a virtual serial port application, the USB version of the AN2295 bootloader has been created to allow reprogramming of Flash memory in the USB stick.

The USB virtual serial port software is fully described in 2., "AN3153 Application note - Using the Full-Speed USB Module on the MCHC908JW32. The MCHC908JW32 bootloader implements the same virtual serial port but under a different PID (the PC sees that serial port as a different application from ZSTAR).

The bootloader drivers installation guide can be found in Section 6.1.2, "AN2295 Bootloader Drivers installation.

5.6.1 Switch to Bootloader procedure

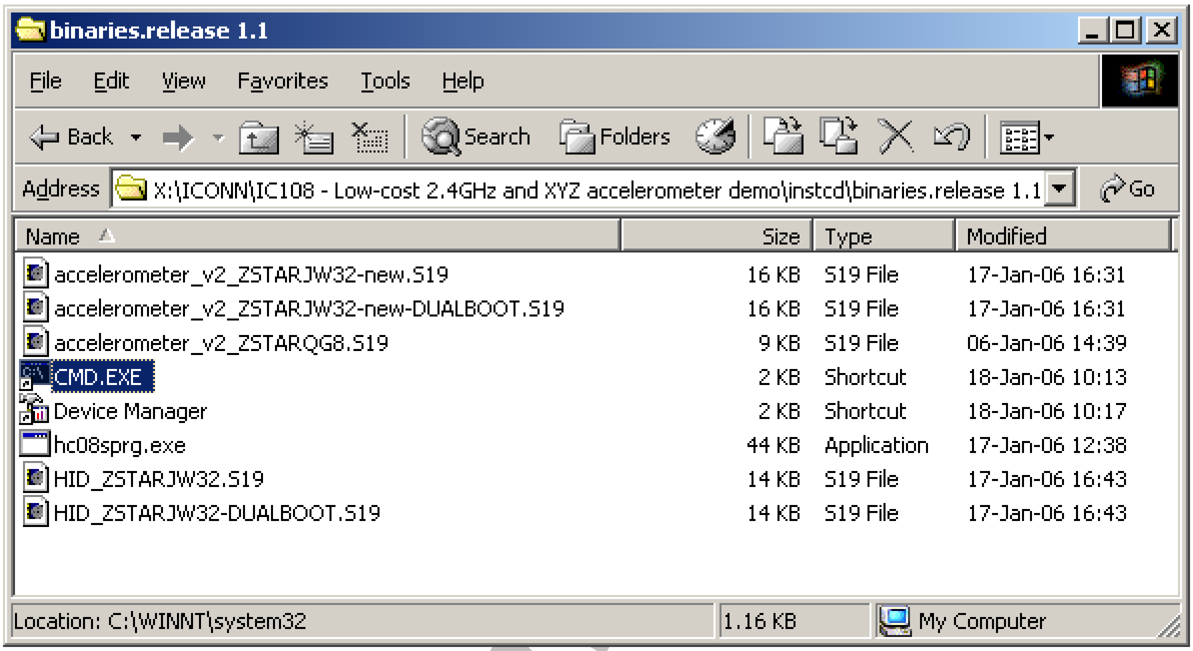
The Bootloader in the ZStar is starts very simply by followed procedure:

1. Unplug the USB Stick from USB port.
2. Press and keep the button on the USB Stick.
3. Keep pressed button and plug the USB Stick back to the USB port.
4. Release the button.

5.6.2 Bootloading Procedure

The easiest way how to Flash newest firmware into USB Stick is use The ZStar3 GUI application and by this application open Bootloader COM port[1]. But if you want proceed Bootloader procedure manually, yhen follow next steps.

1. Find on the installation CD the folder with binaries:



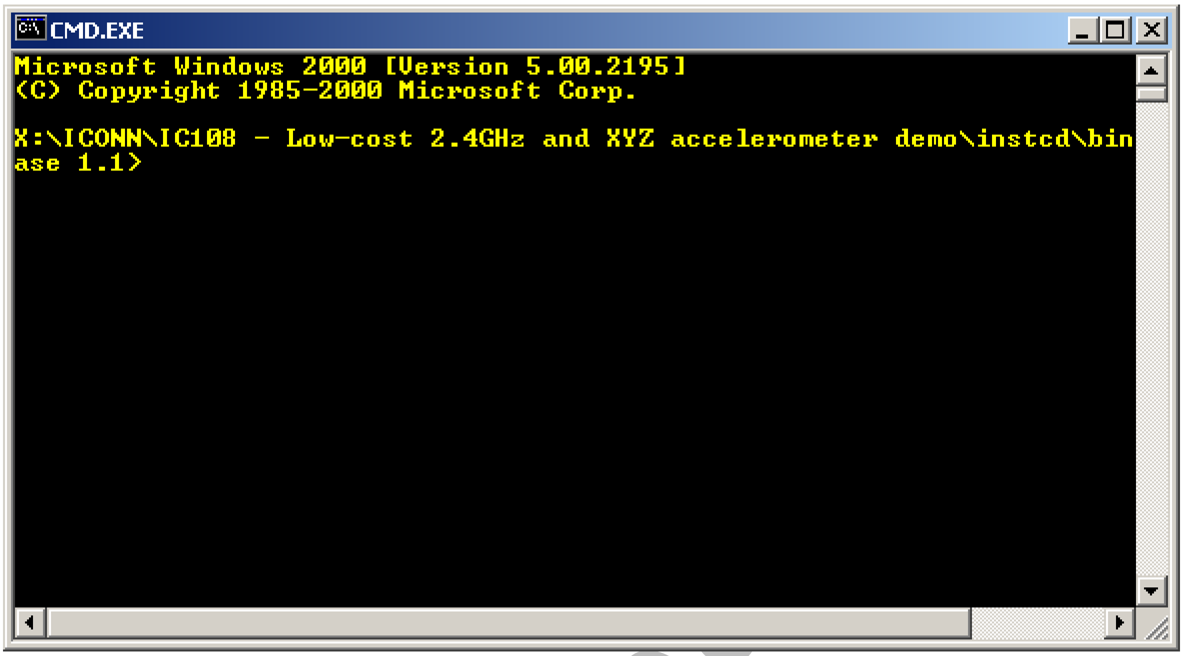
Address X:\ICONN\IC108 - Low-cost 2.4GHz and XYZ accelerometer demo\instcd\binaries.release 1.1

Name	Size	Type	Modified
accelerometer_v2_ZSTARJW32-new.S19	16 KB	S19 File	17-Jan-06 16:31
accelerometer_v2_ZSTARJW32-new-DUALBOOT.S19	16 KB	S19 File	17-Jan-06 16:31
accelerometer_v2_ZSTARQG8.S19	9 KB	S19 File	06-Jan-06 14:39
CMD.EXE	2 KB	Shortcut	18-Jan-06 10:13
Device Manager	2 KB	Shortcut	18-Jan-06 10:17
hc08sprg.exe	44 KB	Application	17-Jan-06 12:38
HID_ZSTARJW32.S19	14 KB	S19 File	17-Jan-06 16:43
HID_ZSTARJW32-DUALBOOT.S19	14 KB	S19 File	17-Jan-06 16:43

Location: C:\WINNT\system32 | 1.16 KB | My Computer

2. Start (double-click) the CMD.EXE shortcut, a command line window should appear:

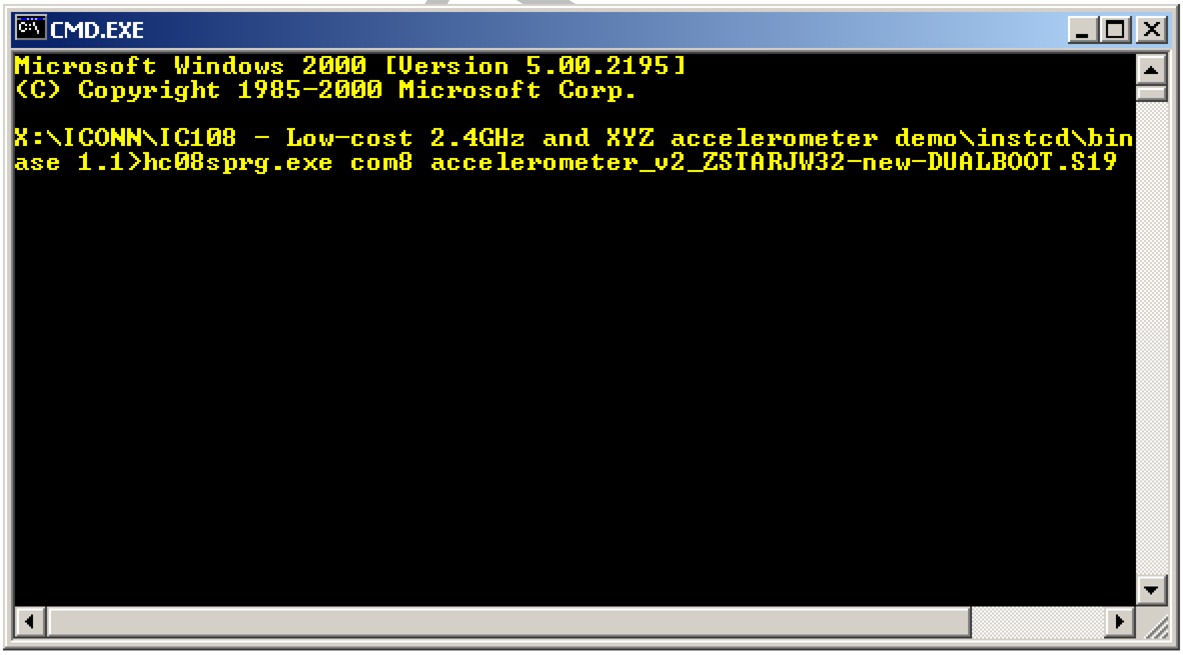
[1] For more details check Chapter 7 of this Manual.



```
Microsoft Windows 2000 [Version 5.00.2195]
(C) Copyright 1985-2000 Microsoft Corp.

X:\ICONN\IC108 - Low-cost 2.4GHz and XYZ accelerometer demo\instcd\bin
ase 1.1>
```

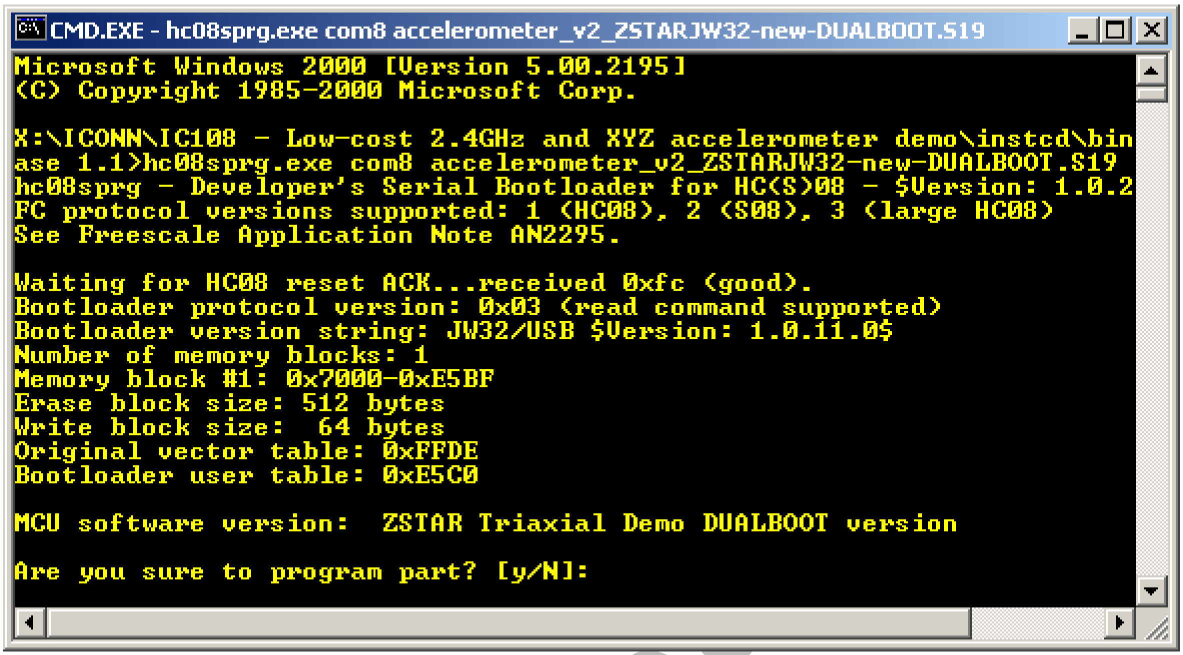
3. Now type: hc08sprg [bootloader com port number] [binary (S file) that you want to bootload], just like this:

```
hc08sprg.exe com8 accelerometer_v2_ZSTARJW32-new-DUALBOOT.S19
```



```
Microsoft Windows 2000 [Version 5.00.2195]
(C) Copyright 1985-2000 Microsoft Corp.

X:\ICONN\IC108 - Low-cost 2.4GHz and XYZ accelerometer demo\instcd\bin
ase 1.1>hc08sprg.exe com8 accelerometer_v2_ZSTARJW32-new-DUALBOOT.S19
```

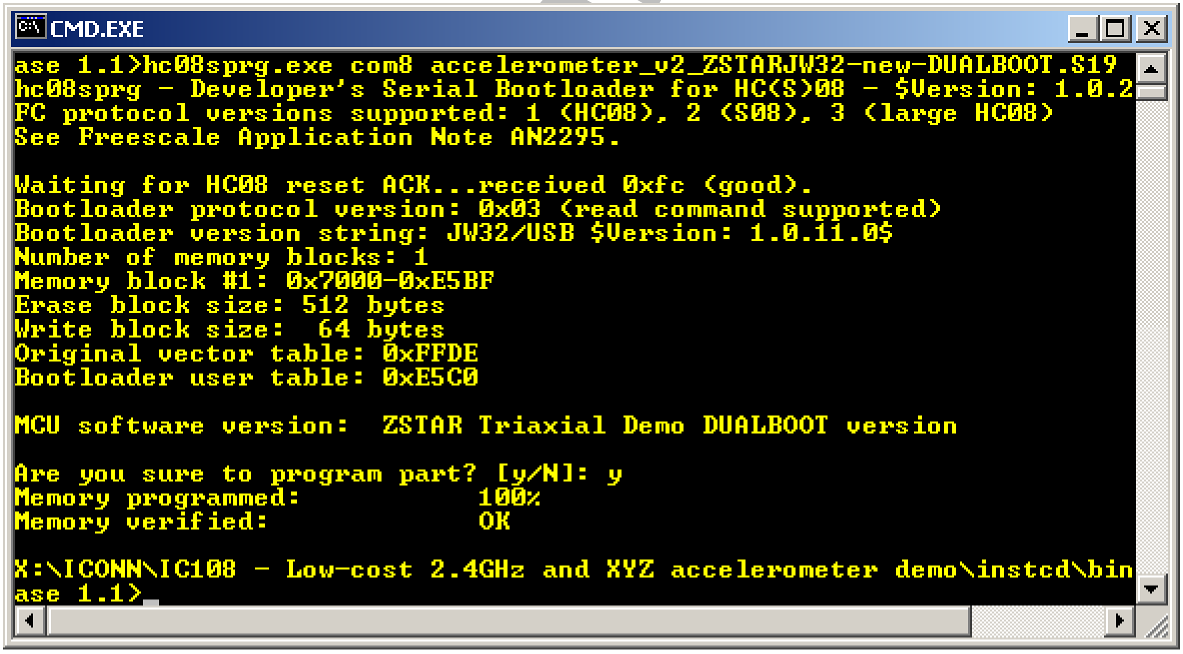
4. Press ENTER and initial bootloader communication will start:



CMD.EXE - hc08sprg.exe com8 accelerometer_v2_ZSTARJW32-new-DUALBOOT.S19

```
Microsoft Windows 2000 [Version 5.00.2195]
(C) Copyright 1985-2000 Microsoft Corp.

X:\ICONN\IC108 - Low-cost 2.4GHz and XYZ accelerometer demo\instcd\bin
ase 1.1>hc08sprg.exe com8 accelerometer_v2_ZSTARJW32-new-DUALBOOT.S19
hc08sprg - Developer's Serial Bootloader for HC(S)08 - $Version: 1.0.2
FC protocol versions supported: 1 (HC08), 2 (S08), 3 (large HC08)
See Freescale Application Note AN2295.

Waiting for HC08 reset ACK...received 0xfc (good).
Bootloader protocol version: 0x03 (read command supported)
Bootloader version string: JW32/USB $Version: 1.0.11.0$
Number of memory blocks: 1
Memory block #1: 0x7000-0xE5BF
Erase block size: 512 bytes
Write block size:  64 bytes
Original vector table: 0xFFDE
Bootloader user table: 0xE5C0

MCU software version:  ZSTAR Triaxial Demo DUALBOOT version

Are you sure to program part? [y/N]:
```

If this screen does not appear, remove the USB stick and start from the beginning.



```
ase 1.1>hc08sprg.exe com8 accelerometer_v2_ZSTARJW32-new-DUALBOOT.S19
hc08sprg - Developer's Serial Bootloader for HC(S)08 - $Version: 1.0.2
FC protocol versions supported: 1 (HC08), 2 (S08), 3 (large HC08)
See Freescale Application Note AN2295.

Waiting for HC08 reset ACK...received 0xfc (good).
Bootloader protocol version: 0x03 (read command supported)
Bootloader version string: JW32/USB $Version: 1.0.11.0$
Number of memory blocks: 1
Memory block #1: 0x7000-0xE5BF
Erase block size: 512 bytes
Write block size:  64 bytes
Original vector table: 0xFFDE
Bootloader user table: 0xE5C0

MCU software version:  ZSTAR Triaxial Demo DUALBOOT version

Are you sure to program part? [y/N]: y
Memory programmed:          100%
Memory verified:            OK

X:\ICONN\IC108 - Low-cost 2.4GHz and XYZ accelerometer demo\instcd\bin
ase 1.1>_
```

The bootloader disappears (in Device Manager) and the newly loaded software starts to execute.

Using this procedure the software in the USB stick can be changed anytime.

5.7 Triapplication software of USB Stick

USB Stick provides three different USB devices that can be changed in runtime. List of ZSTAR USB Devices:

- CDC (Communication Device Class) - virtual serial port.
- HID (Human interface device) - Mouse device
- HID (Human interface device) - Keyboard device

5.7.1 CDC - Virtual Serial Port application

This is main application of ZSTAR3 project. Only this one application can provide ZSTAR3 USB protocol (extended STAR protocol) commands and run all functionalitis and features of ZSTAR3 demo.

5.7.2 HID - Mouse application

The second application of ZSTAR USB Stick is computer mouse demo. This application looks like the real USB mouse. Only Sensor board with index 0 can works as input device. Move of cursor on screen is done very simply by titl of sensor board in axes XY. First two buttons on sensor board has same function as buttons on real mouse. Third button that brings new ZSTAR3 sensor boards substitute a wheel of real mouse. When you keep this button pushed, cursor stops move on screen and USB Stick starts generate wheel movement from Y axis.

5.7.3 HID - Keyboard application

The third application has very specific target of end application, main is controller for simply PC games controlled by keyboard. This application looks like general USB keyboard. The USB stick simulated pressing keys on keyboard by tilt of the sensor boards. ZSTAR recognizes four steps of tilt and by this generated frequency and dury cycle of pressed keys. This feature helps to better game control. ZSTAR suport 6 first Sensor Boards indexes. Each index has assign four keys by table bellow:

Index	Up	Down	Left	Right
0	w	s	a	d
1	t	g	f	h
2	i	k	j	l
3	z	x	c	v
4	b	n	m	p
5	1	2	3	4

Very nice freeware game that we used for testing is GeneRally form http://generally.rscsites.org/ site.

5.7.4 Applications Switching

All embedded application can be switched just by quickly pressing the button (having the USB stick inserted into the USB slot). The applications will appear and disappear accordingly.

The ‘tilt’ mouse application in order to work must have Sensor Board calibrated correctly (e.g. using RD3152MMA7260Q_SW.exe or 5.4.6, “Semiautomatic Self-Calibration procedure).

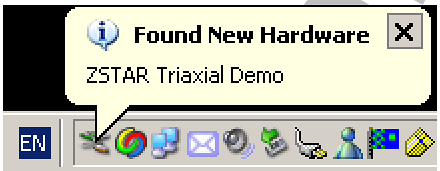
Chapter 6
Application Setup

6.1 ZSTAR3 Installation Procedure

6.1.1 USB stick Installation

First of the all, we have to install the USB stick to your PC. Please follow the next steps.

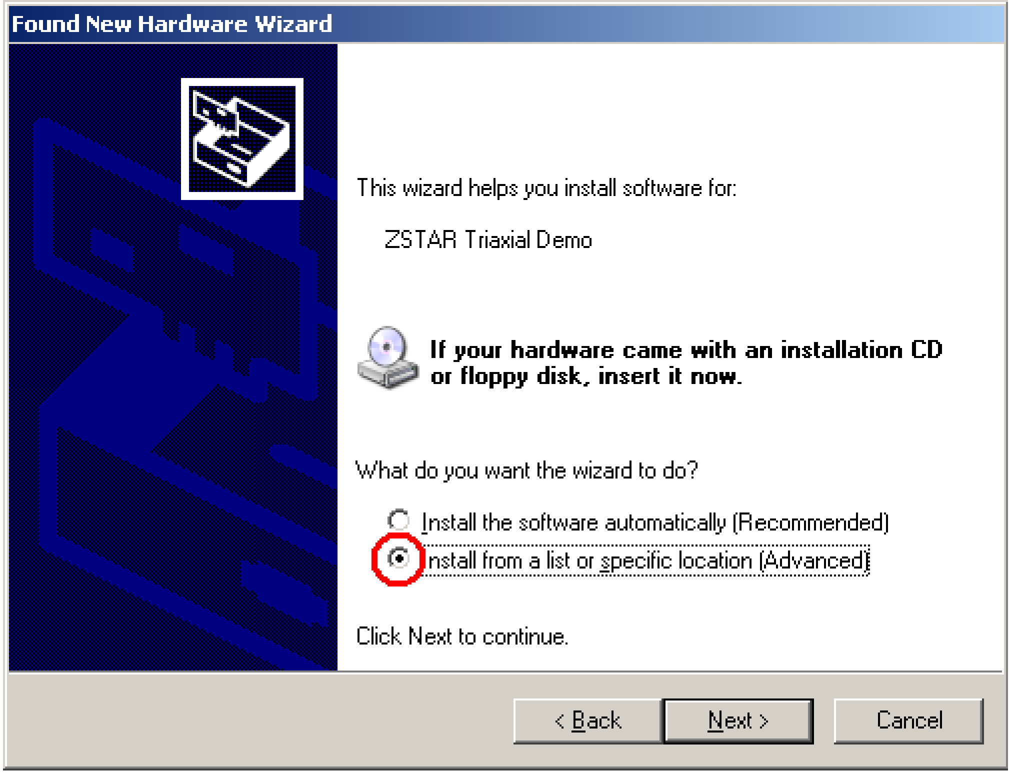
1. Plug the USB stick into a USB slot.The ‘Found New Hardware’ announcement should appear:



Found New Hardware

ZSTAR Triaxial Demo

2. Then the installation wizard starts for new hardware. Choose “Install from a list or special location“



Found New Hardware Wizard

This wizard helps you install software for:

ZSTAR Triaxial Demo

If your hardware came with an installation CD or floppy disk, insert it now.

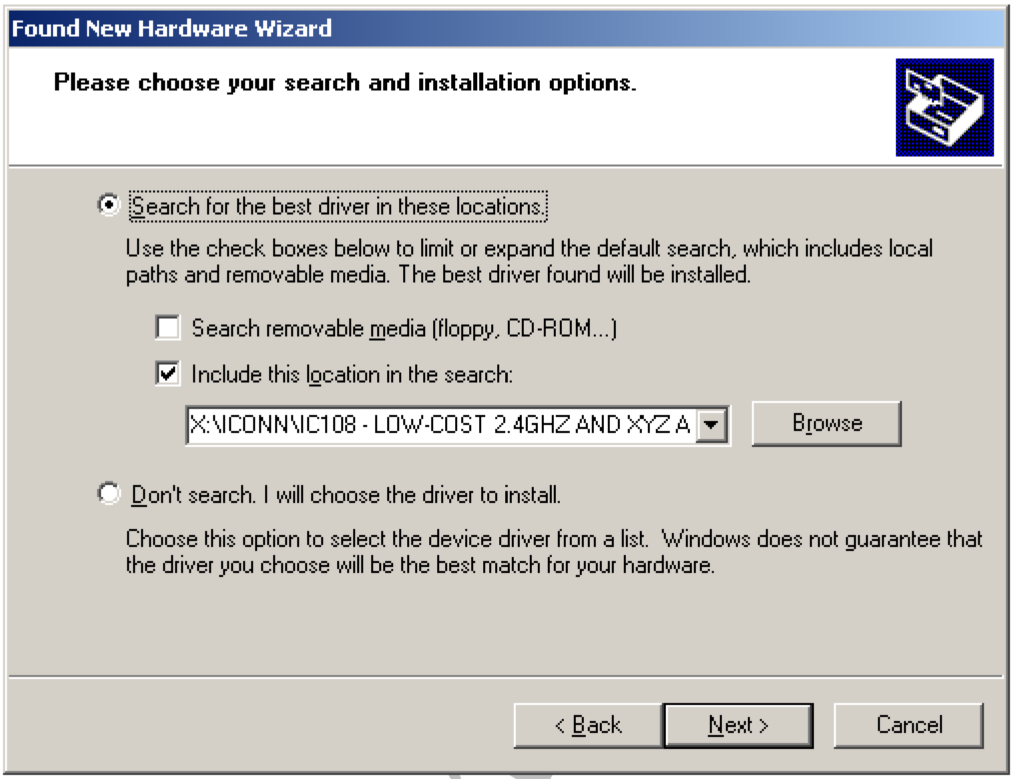
What do you want the wizard to do?

○ Install the software automatically (Recommended)

● Install from a list or specific location (Advanced)

Click Next to continue.

3. Point to the Installation CD as the driver path:



Found New Hardware Wizard

Please choose your search and installation options.

● Search for the best driver in these locations.

Use the check boxes below to limit or expand the default search, which includes local paths and removable media. The best driver found will be installed.

□ Search removable media (floppy, CD-ROM...)

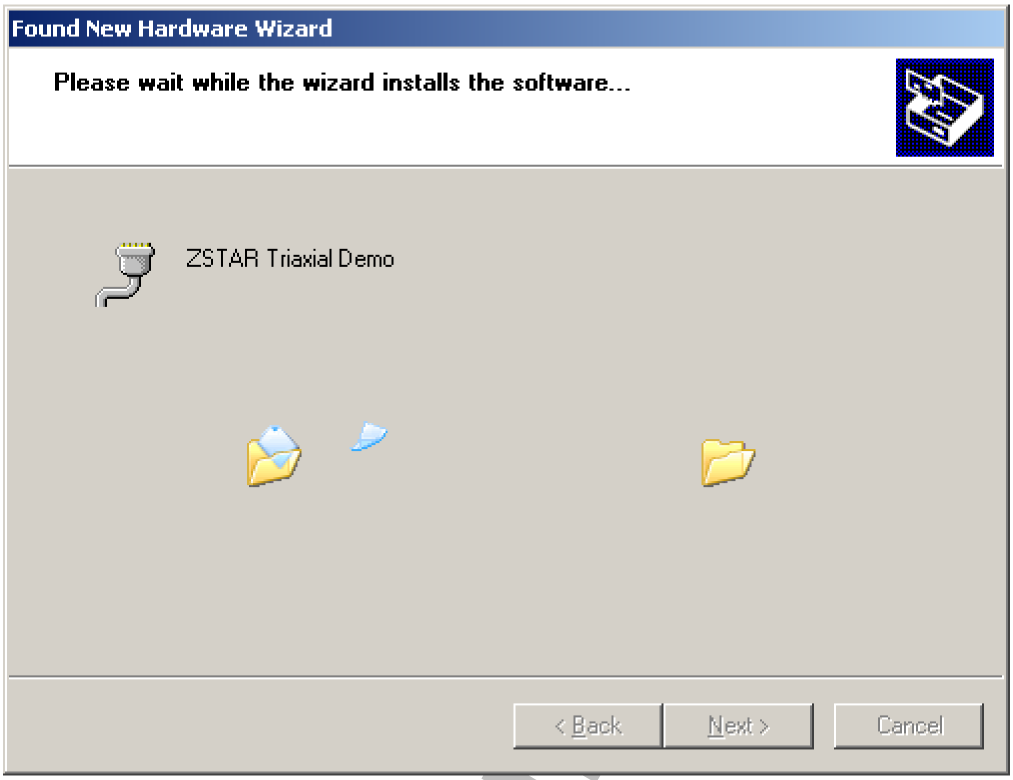
☑ Include this location in the search:

X:\ICONN\IC108 - LOW-COST 2.4GHZ AND XYZ A

○ Don't search. I will choose the driver to install.

Choose this option to select the device driver from a list. Windows does not guarantee that the driver you choose will be the best match for your hardware.

4. Installation should continue:

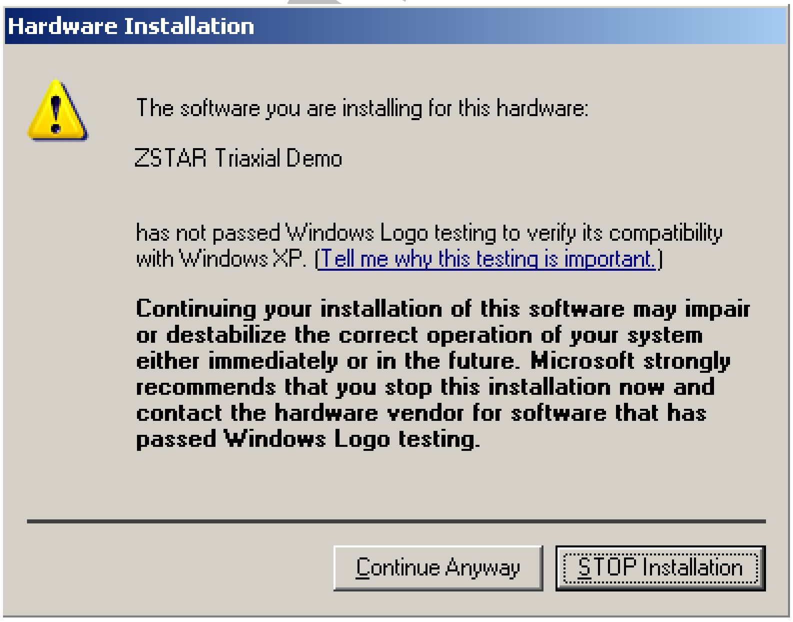


Found New Hardware Wizard

Please wait while the wizard installs the software...

ZSTAR Triaxial Demo

5. If you are asked to stop or continue installation because the drivers are not certified by Microsoft, select the “Continue Anyway” button.



Hardware Installation

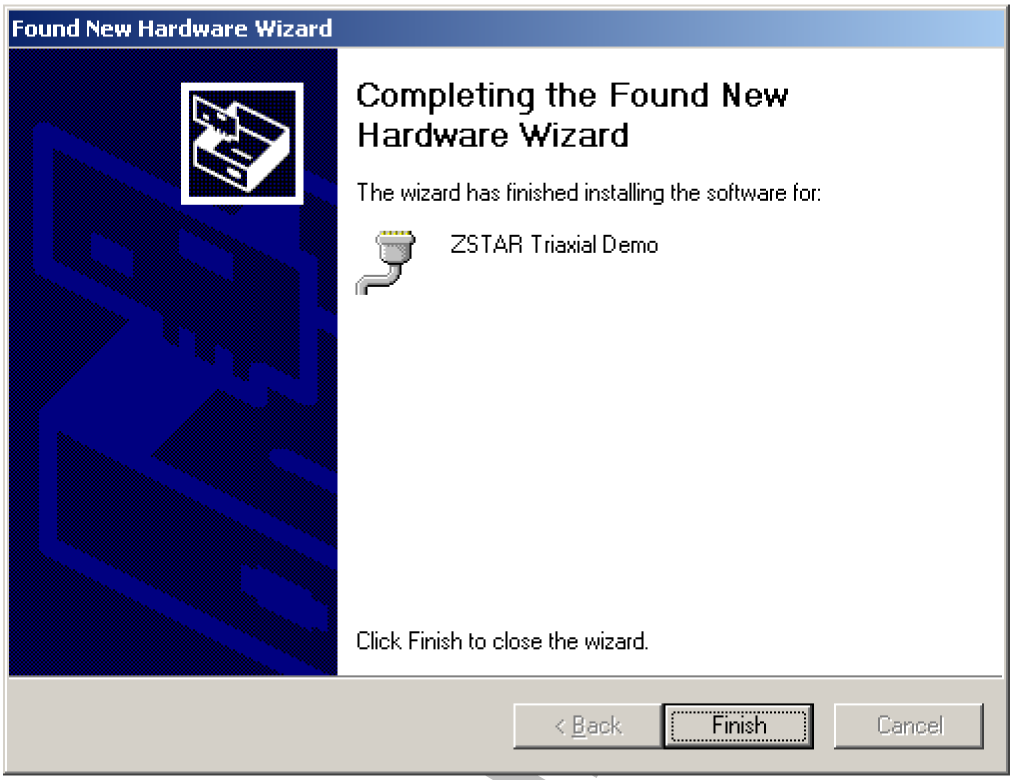
The software you are installing for this hardware:

ZSTAR Triaxial Demo

has not passed Windows Logo testing to verify its compatibility with Windows XP. (Tell me why this testing is important.)

Continuing your installation of this software may impair or destabilize the correct operation of your system either immediately or in the future. Microsoft strongly recommends that you stop this installation now and contact the hardware vendor for software that has passed Windows Logo testing.

6. Installation should successfully finish.



Found New Hardware Wizard

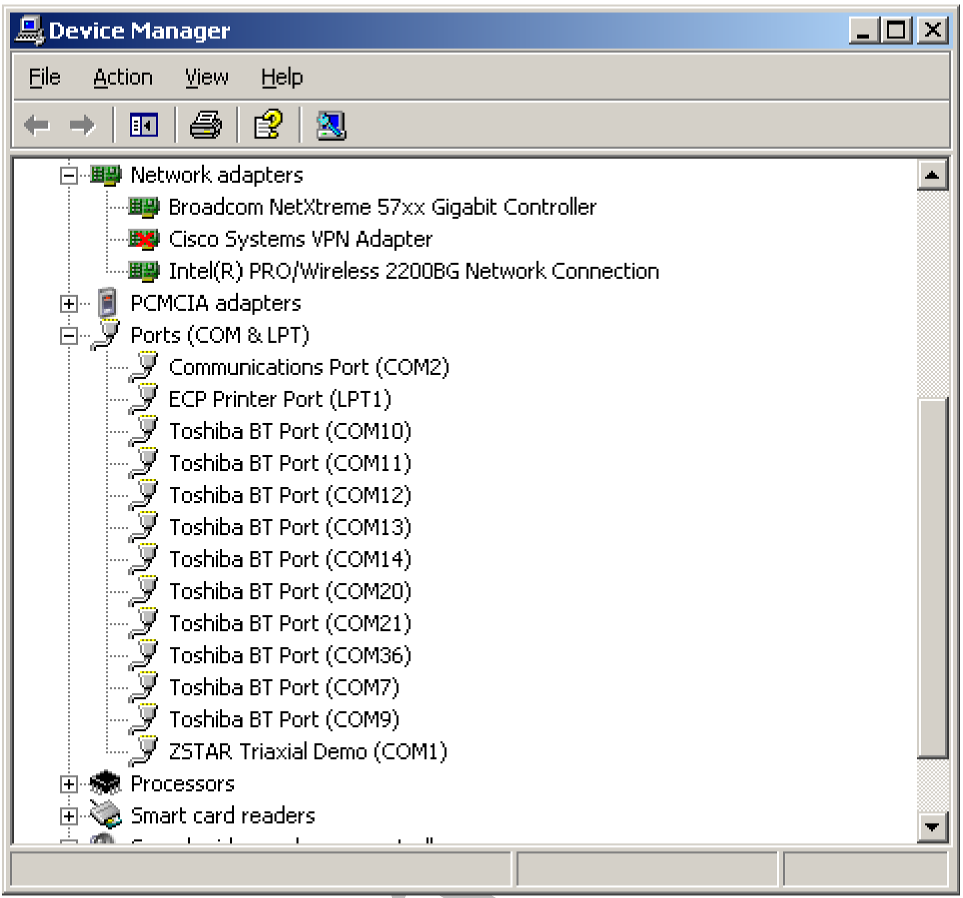
Completing the Found New Hardware Wizard

The wizard has finished installing the software for:

ZSTAR Triaxial Demo

Click Finish to close the wizard.

7. Check whether a new serial port (ZSTAR Triaxial Demo) has appeared in your Device Manager (Right click **My computer** on the Desktop > **Properties**, **Hardware** tab, **Device Manager** button):



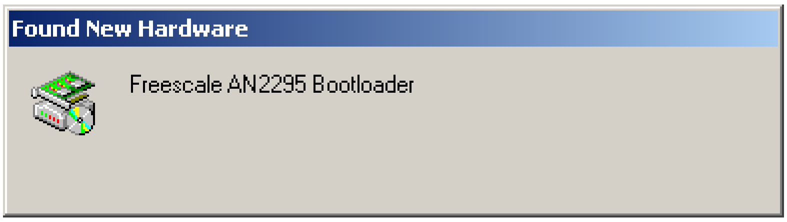
- Network adapters
  - Broadcom NetXtreme 57xx Gigabit Controller
  - Cisco Systems VPN Adapter
  - Intel(R) PRO/Wireless 2200BG Network Connection
- PCMCIA adapters
- Ports (COM & LPT)
  - Communications Port (COM2)
  - ECP Printer Port (LPT1)
  - Toshiba BT Port (COM10)
  - Toshiba BT Port (COM11)
  - Toshiba BT Port (COM12)
  - Toshiba BT Port (COM13)
  - Toshiba BT Port (COM14)
  - Toshiba BT Port (COM20)
  - Toshiba BT Port (COM21)
  - Toshiba BT Port (COM36)
  - Toshiba BT Port (COM7)
  - Toshiba BT Port (COM9)
  - ZSTAR Triaxial Demo (COM1)
- Processors
- Smart card readers

6.1.2 AN2295 Bootloader Drivers installation

This procedure assumes that ZSTAR Demo drivers are already installed. The drivers are false common for the bootloader (= are already present in Windows folders). If not, the procedure will be identical to the ZSTAR drivers installation.

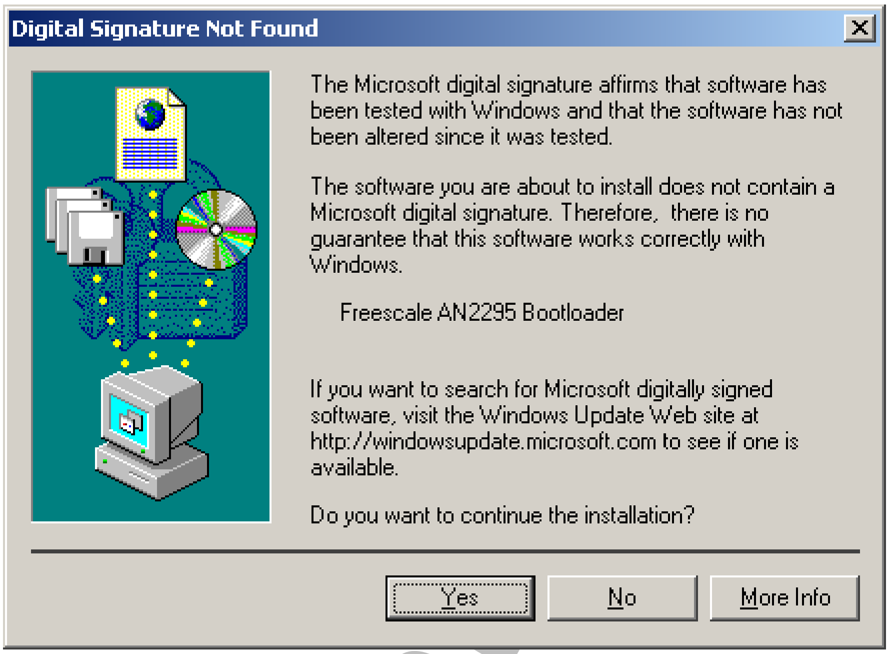
1. Press the Button on the USB stick and insert it into a USB connector (keeping the button pressed when inserted).

The following window appears:



Freescale AN2295 Bootloader

2. The PC searches for an appropriate driver (as the ZSTAR Demo, in some instances a folder with drivers (`zstar.inf` and `usbser-zstar.sys`) needs to be selected), then the following window should appear:



Digital Signature Not Found

The Microsoft digital signature affirms that software has been tested with Windows and that the software has not been altered since it was tested.

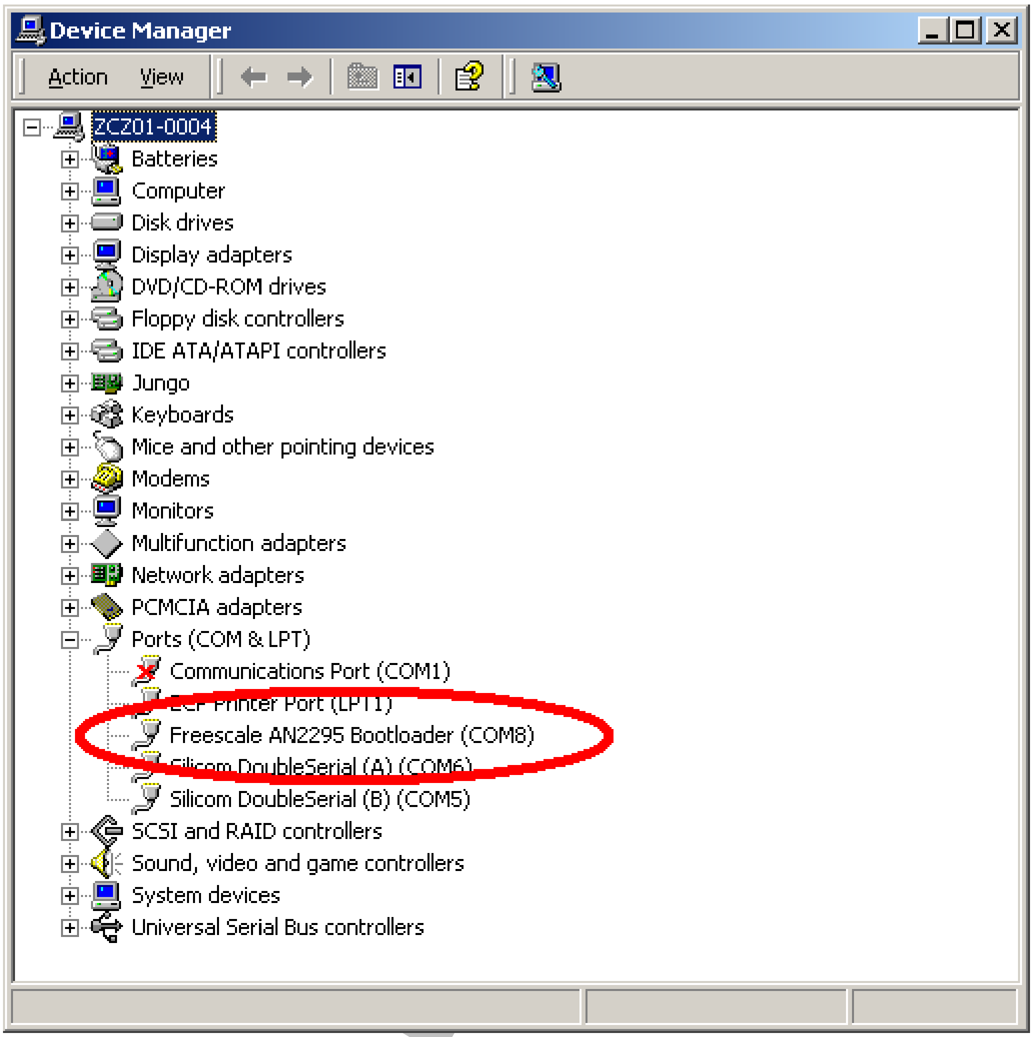
The software you are about to install does not contain a Microsoft digital signature. Therefore, there is no guarantee that this software works correctly with Windows.

Freescale AN2295 Bootloader

If you want to search for Microsoft digitally signed software, visit the Windows Update Web site at http://windowsupdate.microsoft.com to see if one is available.

Do you want to continue the installation?

3. Just click Yes, and the bootloader port will be installed (as seen in the Device manager):
4. Right click **My computer** on the Desktop > **Properties**, **Hardware** tab, **Device Manager** button.
5. A similar setup should be observed:



```
ZCZ01-0004
    Batteries
    Computer
    Disk drives
    Display adapters
    DVD/CD-ROM drives
    Floppy disk controllers
    IDE ATA/ATAPI controllers
    Jungo
    Keyboards
    Mice and other pointing devices
    Modems
    Monitors
    Multifunction adapters
    Network adapters
    PCMCIA adapters
    Ports (COM & LPT)
        Communications Port (COM1)
        ECP Printer Port (LPT1)
        Freescale AN2295 Bootloader (COM8)
        Silicom DoubleSerial (A) (COM6)
        Silicom DoubleSerial (B) (COM5)
    SCSI and RAID controllers
    Sound, video and game controllers
    System devices
    Universal Serial Bus controllers
```

6. Note down the COM port number (here, COM8); this is the port number of the Bootloader

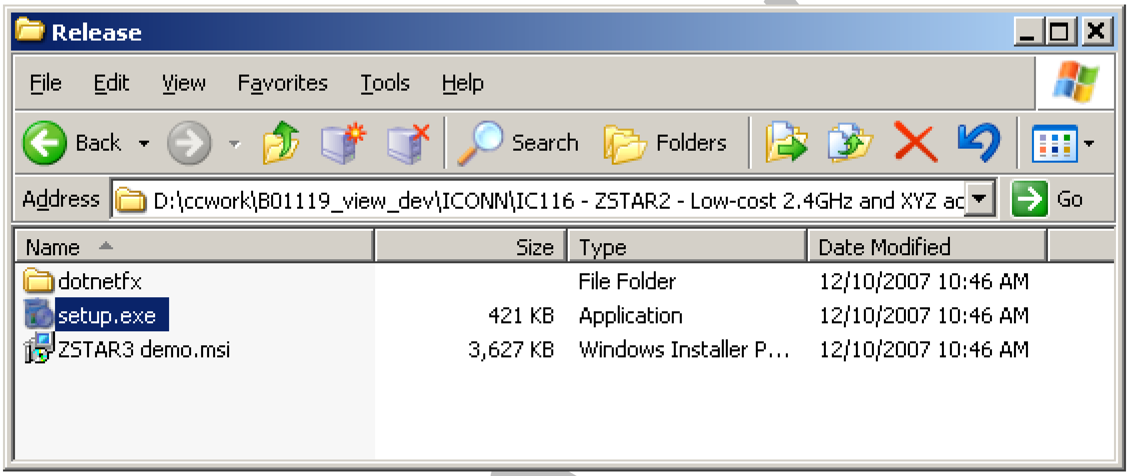
Once the software in the USB stick needs to be updated, the Bootloader can be invoked anytime, just by pressing the button while inserting the USB stick into the USB slot.

Chapter 7 ZSTAR3 GUI

ZSTAR3 demo brings new GUI that supports all new features and functions. It’s distibuted as complete installation package with all neccesary files, includes Microsoft .NET Framework package.

7.1 Installation

1. Run setup.exe file in installation directory to start installation of ZStar3 GUI to computer.

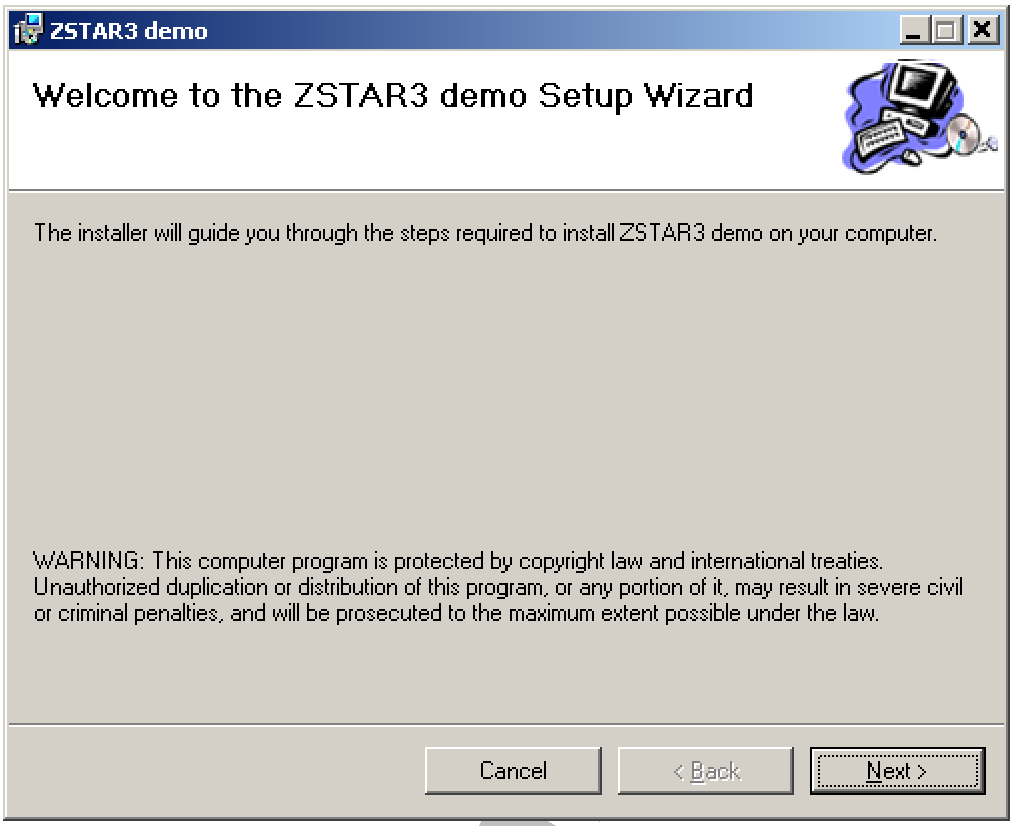


D:\ccwork\B01119_view_dev\ICONN\IC116 - ZSTAR2 - Low-cost 2.4GHz and XYZ ac

Name	Size	Type	Date Modified
dotnetfx		File Folder	12/10/2007 10:46 AM
setup.exe	421 KB	Application	12/10/2007 10:46 AM
ZSTAR3 demo.msi	3,627 KB	Windows Installer P...	12/10/2007 10:46 AM

Figure 7-1. Installation files

2. On first screen of ZStar3 installation packege only press “next“ button.



ZSTAR3 demo

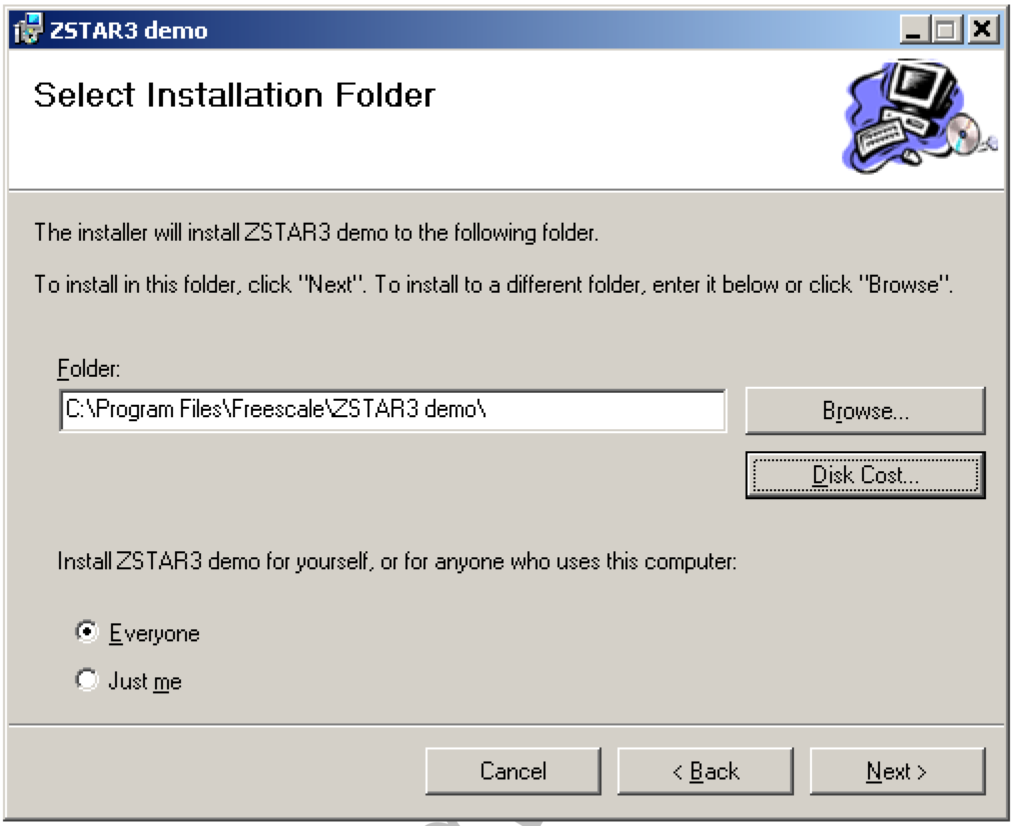
Welcome to the ZSTAR3 demo Setup Wizard

The installer will guide you through the steps required to install ZSTAR3 demo on your computer.

WARNING: This computer program is protected by copyright law and international treaties. Unauthorized duplication or distribution of this program, or any portion of it, may result in severe civil or criminal penalties, and will be prosecuted to the maximum extent possible under the law.

Figure 7-2. Start of installation

3. In this step select destination directory and some others posibilities and press “next“ button. Please follow all next steps to get to end of installation process.



ZSTAR3 demo

Select Installation Folder

The installer will install ZSTAR3 demo to the following folder.

To install in this folder, click "Next". To install to a different folder, enter it below or click "Browse".

Folder: C:\Program Files\Freescale\ZSTAR3 demo\

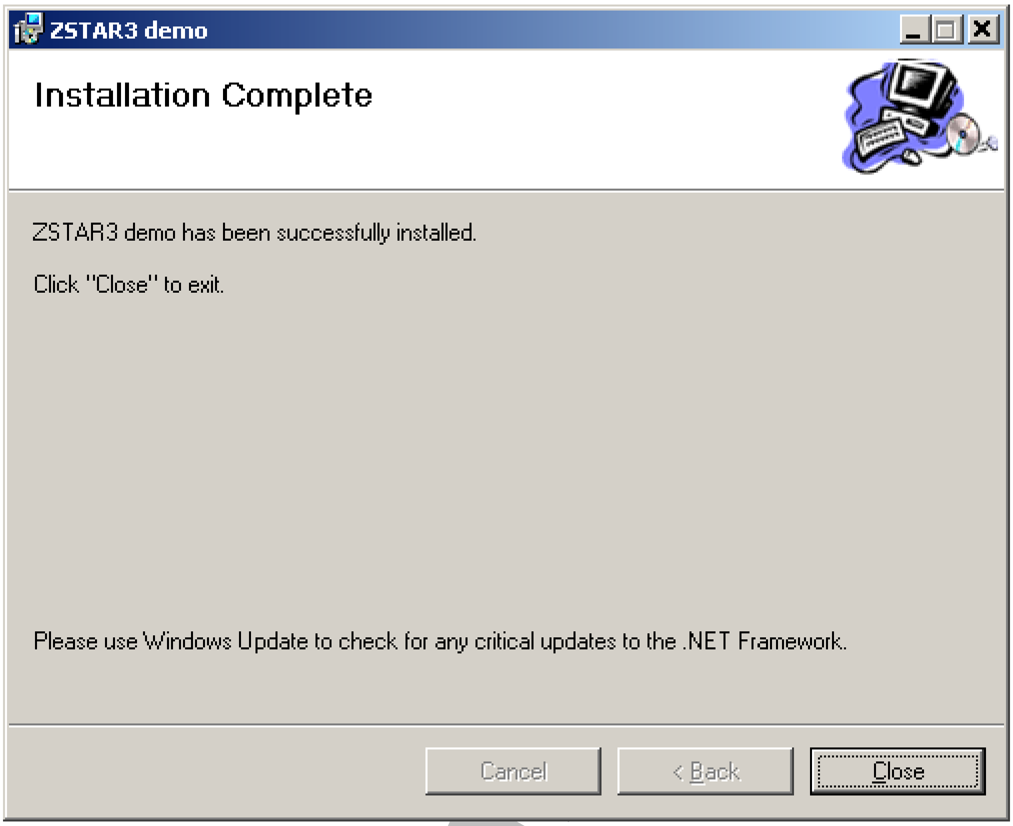
Install ZSTAR3 demo for yourself, or for anyone who uses this computer:

● Everyone

○ Just me

Figure 7-3. Second step of installation process - select destionation directory

4. Finish step of the installation process.



ZSTAR3 demo

Installation Complete

ZSTAR3 demo has been successfully installed.

Click "Close" to exit.

Please use Windows Update to check for any critical updates to the .NET Framework.

Figure 7-4. Last step of the installation process

7.2 ZSTAR3 GUI

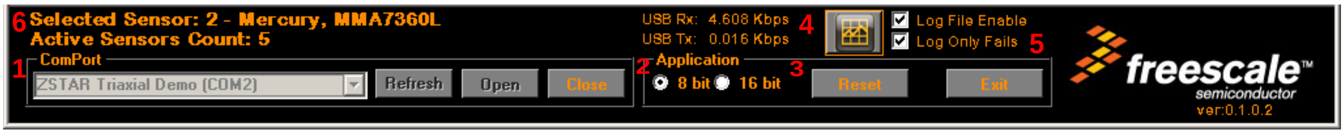
The ZSTAR3 GUI is specially designed PC application for Freescale ZStar demos. It’s fully supports all new functionalitis of the ZSTAR demo and all available ZSTAR boards.

7.2.1 Features of ZSTAR GUI

- Support 16 sensors on one screen. Shows for each sensor basic information includes current acceleration values and freefall events.
- Easy select of active sensor board.
- Detail window of selected sensor board on overview screen.
- RF page that shows all RF settings and informations. RF settings as the Netnum, RF channel are modicable by this screen.
- Lot of various demos of typical accelerometers applications or Freescale sensors presentation.
- User help by about screens in most of demo windows.
- Update function for old ZSTAR USB Sticks. The GUI can reflash all old USB Stick boards with newest software that is compatible with software of old Sensor boards.
- USB data flow monitor

7.2.2 The ZStar3 GUI main controls

This panel is visible on all tabs of ZStar3 GUI application. It shows the most important controls and information of ZStar demo.



Selected Sensor: 2 - Mercury, MMA7360L
Active Sensors Count: 5

USB Rx: 4.608 Kbps
USB Tx: 0.016 Kbps

ComPort: ZSTAR Triaxial Demo (COM2)

Application: ● 8 bit ● 16 bit

☑ Log File Enable
☑ Log Only Fails

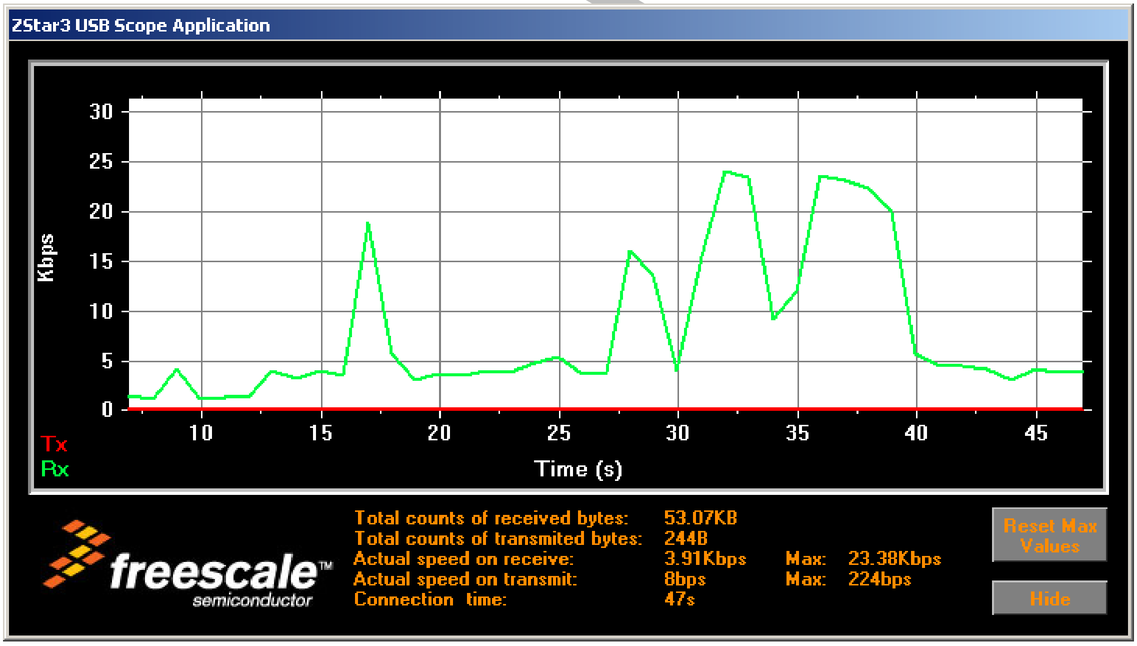
Figure 7-5. The ZStar3 GUI main controls

The GUI main controls[1]:

1. USB Stick connection panel.
2. The ZStar resolution switch 8/16 bits.
3. Reset of the ZStar hardware.
4. USB data flow monitor.
5. Log file controls.
6. Information of count of total connected sensor boards and currently selected one.

7.2.2.1 USB Data Flow monitor

This is special window designed for Monitoring data rates of communication via USB interface[2]. Window shows all baic information of current USB load and its draw graph of last 40 seconds.



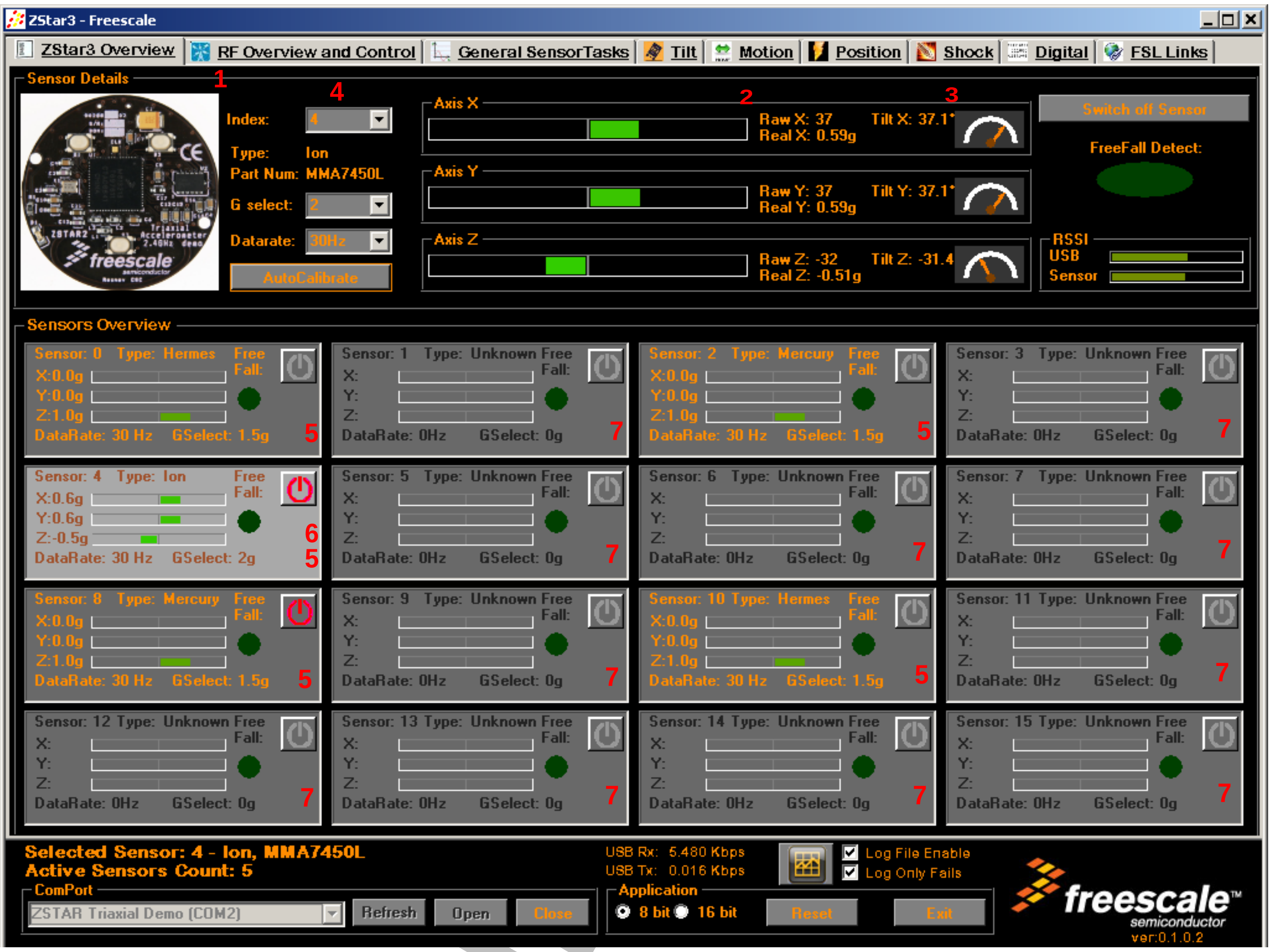
ZStar3 USB Scope Application

Total counts of received bytes: 53.07KB
Total counts of transmited bytes: 244B
Actual speed on receive: 3.91Kbps Max: 23.38Kbps
Actual speed on transmit: 8bps Max: 224bps
Connection time: 47s

Figure 7-6. USB Data Flow Monitor

[1] Red numbers in picture marks individual controls described in list below.
[2] Only user payload - ZStar data.

7.2.3 Sensor Board overview screen



Index: 4
Type: Ion
Part Num: MMA7450L
G select: 2
Datarate: 30Hz

Raw X: 37 Tilt X: 37.1°
Real X: 0.59g
Raw Y: 37 Tilt Y: 37.1°
Real Y: 0.59g
Raw Z: -32 Tilt Z: -31.4
Real Z: -0.51g

FreeFall Detect:

RSSI
USB
Sensor

Sensor: 0 Type: Hermes Free Fall: X:0.0g Y:0.0g Z:1.0g DataRate: 30 Hz GSelect: 1.5g

Sensor: 1 Type: Unknown Free Fall: X: Y: Z: DataRate: 0Hz GSelect: 0g

Sensor: 2 Type: Mercury Free Fall: X:0.0g Y:0.0g Z:1.0g DataRate: 30 Hz GSelect: 1.5g

Sensor: 3 Type: Unknown Free Fall: X: Y: Z: DataRate: 0Hz GSelect: 0g

Sensor: 4 Type: Ion Free Fall: X:0.6g Y:0.6g Z:-0.5g DataRate: 30 Hz GSelect: 2g

Sensor: 5 Type: Unknown Free Fall: X: Y: Z: DataRate: 0Hz GSelect: 0g

Sensor: 6 Type: Unknown Free Fall: X: Y: Z: DataRate: 0Hz GSelect: 0g

Sensor: 7 Type: Unknown Free Fall: X: Y: Z: DataRate: 0Hz GSelect: 0g

Sensor: 8 Type: Mercury Free Fall: X:0.0g Y:0.0g Z:1.0g DataRate: 30 Hz GSelect: 1.5g

Sensor: 9 Type: Unknown Free Fall: X: Y: Z: DataRate: 0Hz GSelect: 0g

Sensor: 10 Type: Hermes Free Fall: X:0.0g Y:0.0g Z:1.0g DataRate: 30 Hz GSelect: 1.5g

Sensor: 11 Type: Unknown Free Fall: X: Y: Z: DataRate: 0Hz GSelect: 0g

Sensor: 12 Type: Unknown Free Fall: X: Y: Z: DataRate: 0Hz GSelect: 0g

Sensor: 13 Type: Unknown Free Fall: X: Y: Z: DataRate: 0Hz GSelect: 0g

Sensor: 14 Type: Unknown Free Fall: X: Y: Z: DataRate: 0Hz GSelect: 0g

Sensor: 15 Type: Unknown Free Fall: X: Y: Z: DataRate: 0Hz GSelect: 0g

Selected Sensor: 4 - Ion, MMA7450L
Active Sensors Count: 5

USB Rx: 5.480 Kbps
USB Tx: 0.016 Kbps

☑ Log File Enable
☑ Log Only Fails

ComPort: ZSTAR Triaxial Demo (COM2)

Application: ○ 8 bit ● 16 bit

ver:0.1.0.2

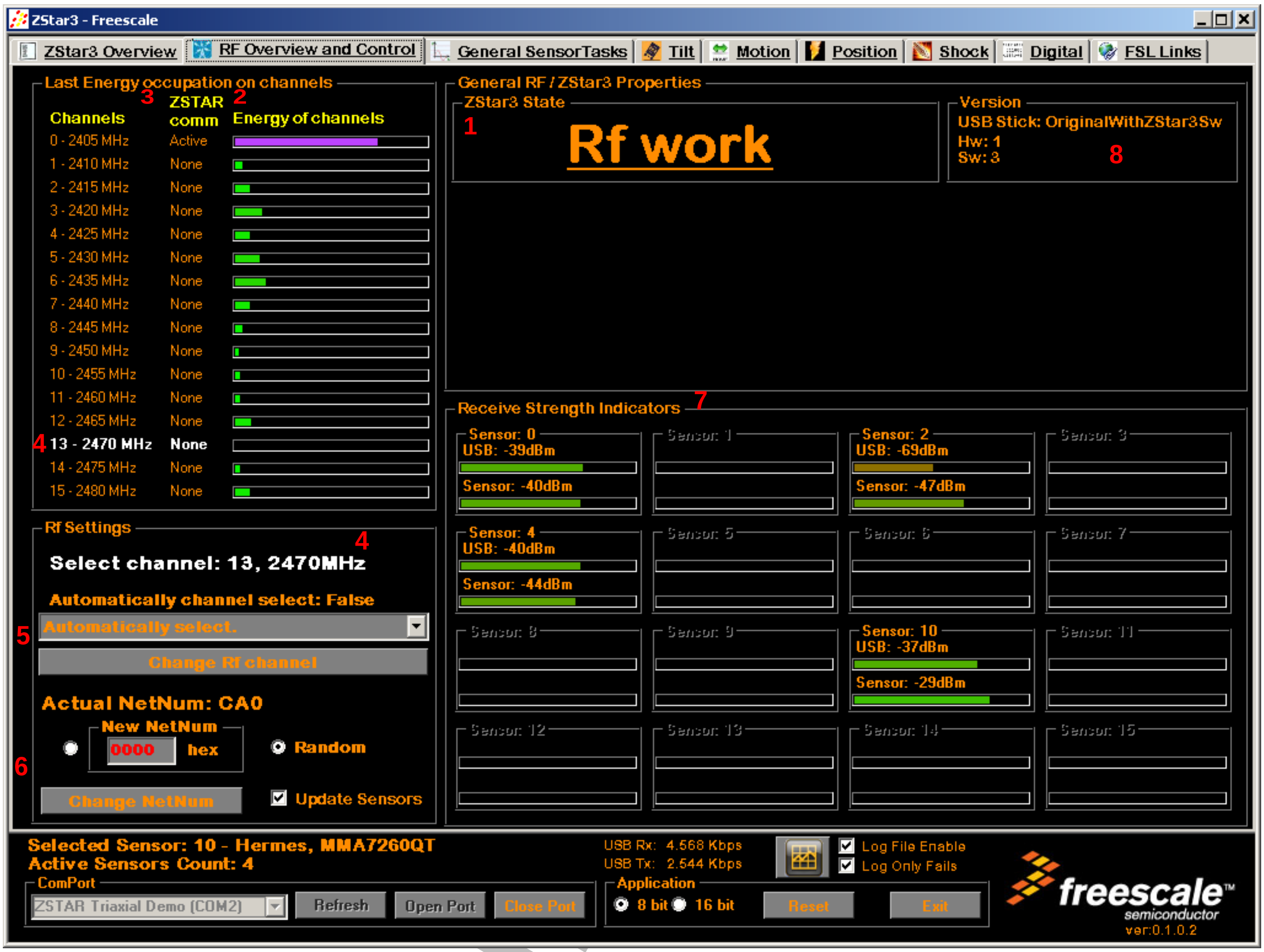
Figure 7-7. Main sensor board overview screen of the GUI

The GUI main sensor board overview controls[1]:

1. Detail panel of Selected sensor board.
2. Current accelerometric data in graphical and text form.
3. Current tilt of selected board in graphical and text form.
4. Basic settings of selected sensor board.
5. Log file controls.
6. Currently connected sensors
7. Selected active sensor board.
8. Free slots for Sensor boards.

[1] Red numbers in picture marks individual controls described in list below.

7.2.4 RF overview screen



Last Energy occupation on channels

Channels	ZSTAR comm	Energy of channels
0 - 2405 MHz	Active	
1 - 2410 MHz	None	
2 - 2415 MHz	None	
3 - 2420 MHz	None	
4 - 2425 MHz	None	
5 - 2430 MHz	None	
6 - 2435 MHz	None	
7 - 2440 MHz	None	
8 - 2445 MHz	None	
9 - 2450 MHz	None	
10 - 2455 MHz	None	
11 - 2460 MHz	None	
12 - 2465 MHz	None	
13 - 2470 MHz	**None**	
14 - 2475 MHz	None	
15 - 2480 MHz	None	

General RF / ZStar3 Properties

ZStar3 State: Rf work

Version
USB Stick: OriginalWithZStar3Sw
Hw: 1
Sw: 3

Rf Settings

Select channel: 13, 2470MHz

Automatically channel select: False

Automatically select.

Actual NetNum: CA0

New NetNum: ○ 0000 hex ● Random

☑ Update Sensors

Receive Strength Indicators

Sensor: 0 USB: -39dBm Sensor: -40dBm
Sensor: 1
Sensor: 2 USB: -69dBm Sensor: -47dBm
Sensor: 3
Sensor: 4 USB: -40dBm Sensor: -44dBm
Sensor: 5
Sensor: 6
Sensor: 7
Sensor: 8
Sensor: 9
Sensor: 10 USB: -37dBm Sensor: -29dBm
Sensor: 11
Sensor: 12
Sensor: 13
Sensor: 14
Sensor: 15

Selected Sensor: 10 - Hermes, MMA7260QT
Active Sensors Count: 4

ComPort: ZSTAR Triaxial Demo (COM2)

USB Rx: 4.568 Kbps
USB Tx: 2.544 Kbps

☑ Log File Enable
☑ Log Only Fails

Application ● 8 bit ○ 16 bit

ver:0.1.0.2

Figure 7-8. RF overview screen

The GUI RF overview controls[1]:

1. Current work state of the ZStar demo.
2. Last measured information about occupations of indidual RF channels.
3. Flags of detected other ZStar communication on other channels.
4. Current used RF channel.
5. RF channel change control.
6. Netnum of RF communication change control.
7. RSSI[2] informations of all connected sensors.
8. Versions of the Demo.

[1] Red numbers in picture marks individual controls described in list below.

[2] Receive signal strength information.

7.2.5 General sensor tasks

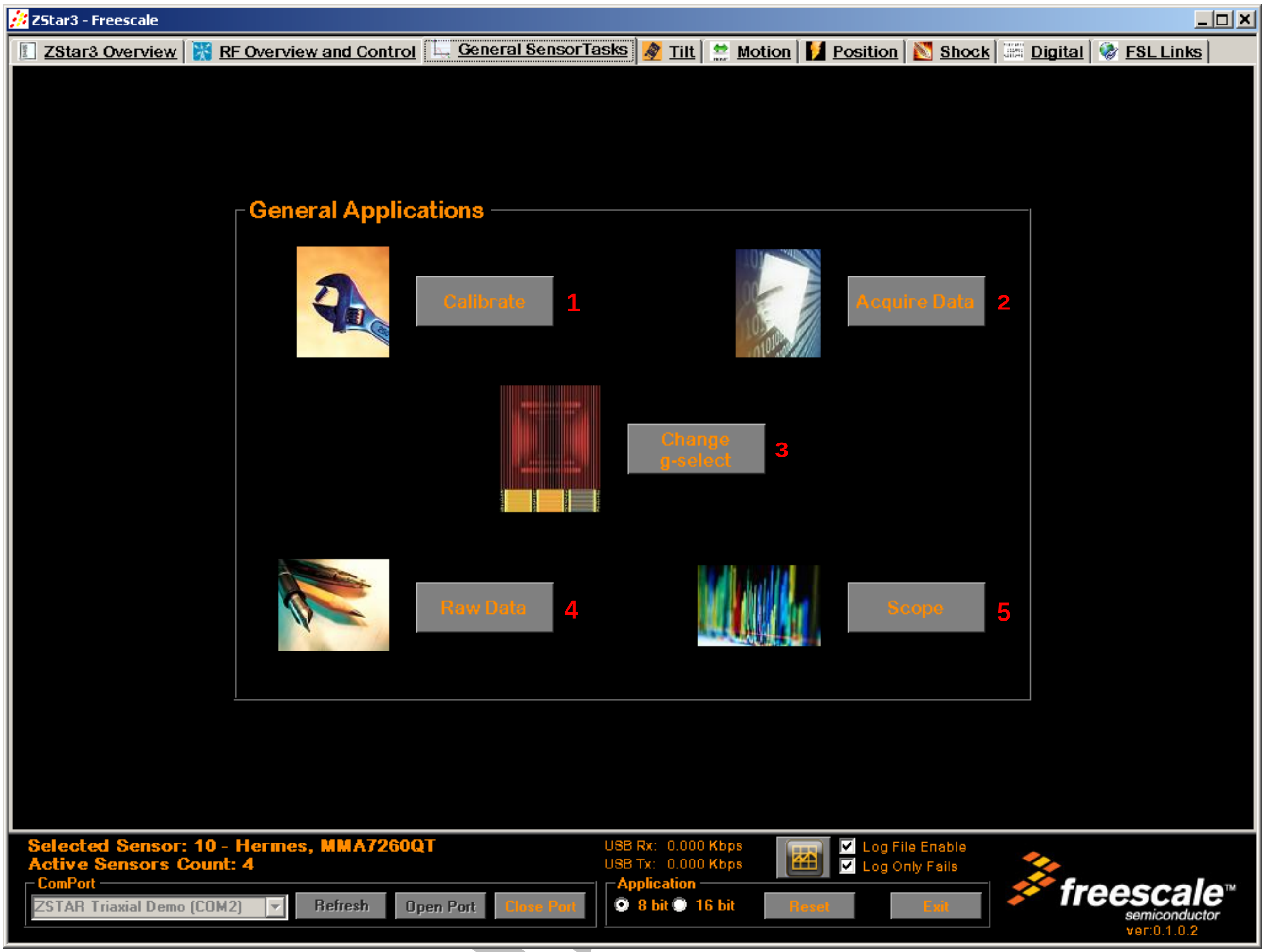


Figure 7-9. The General sensor tasks screen.

The GUI General sensor tasks controls[1]:

1. Calibration screen - This screen allowed with more detail calibrate sensor on selected Sensor Board.
2. Acqire data screen - This application of the ZStar provides a acquire data of all connected sensors into Excel or text file.
3. Change g select screen - This screen allowed simply change of current g range on selected sensor board.
4. Raw data screen - This screen shows basic data of Sensor board in general text format.
5. Scope window - This is very usefull window that it shows acceleration in various formats selectable by user.

[1] Red numbers in picture marks individual controls described in list below.

7.2.5.1 Scope demo application

This demo application shows graphical outputs of measured and computed values from selected sensor board.It can shows unchanged raw data received direct from sensors or computed values in g. This window as well provides computed absolute value from all three axes. All computed values can be displayed as filtered.

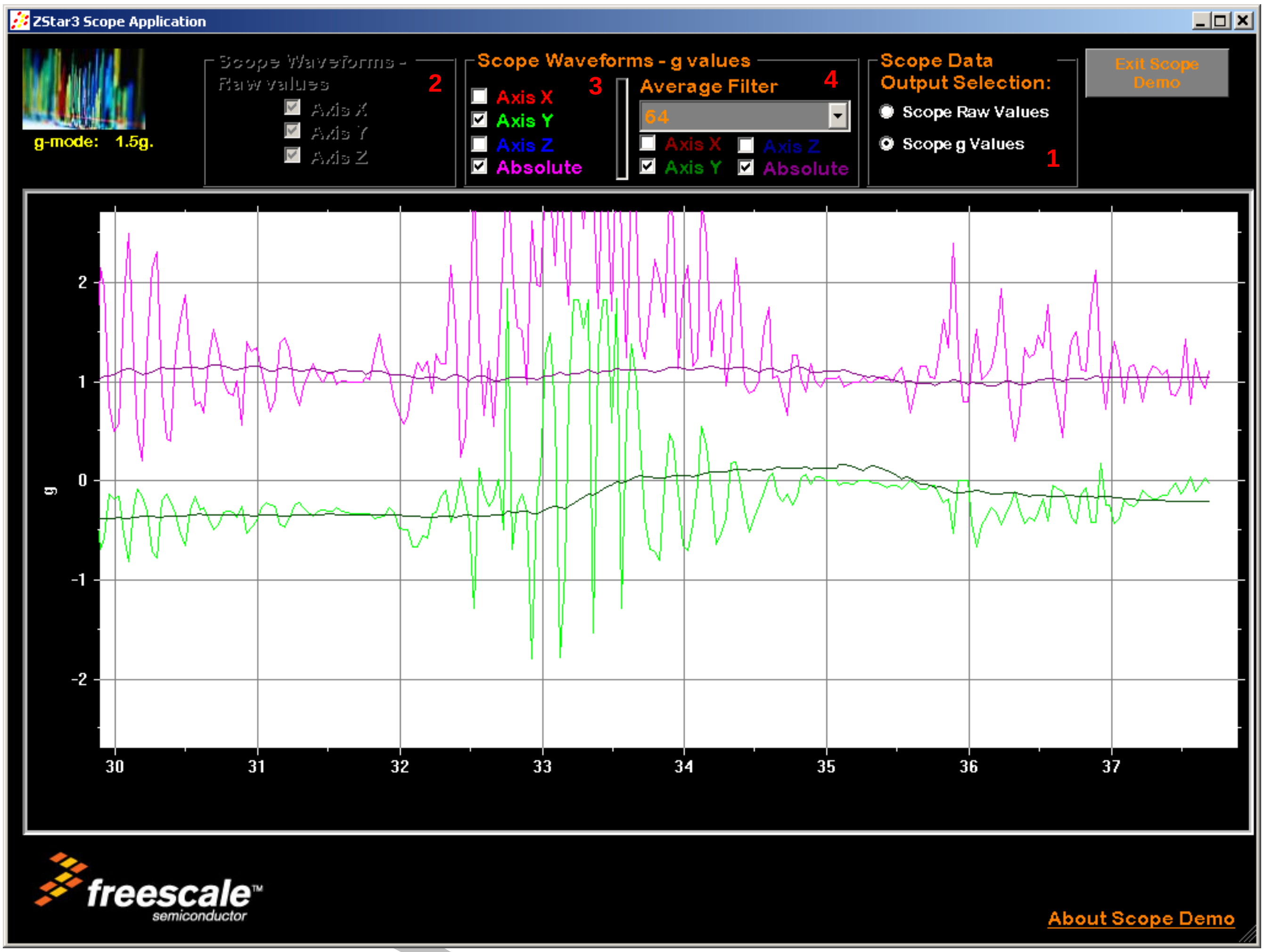


Figure 7-10. Scope window application

The Scope window application controls[1]:

1. Data source selection - Select which data will be dispalyed, RAW or REAL.
2. Raw data panel - in this panel you can select which axes will be displayed.
3. Real data panel - in this panel you can select which axes will be displayed.
4. Filtered real data panel - in this panel you can select which filtered axes will be displayed and order of average filter.

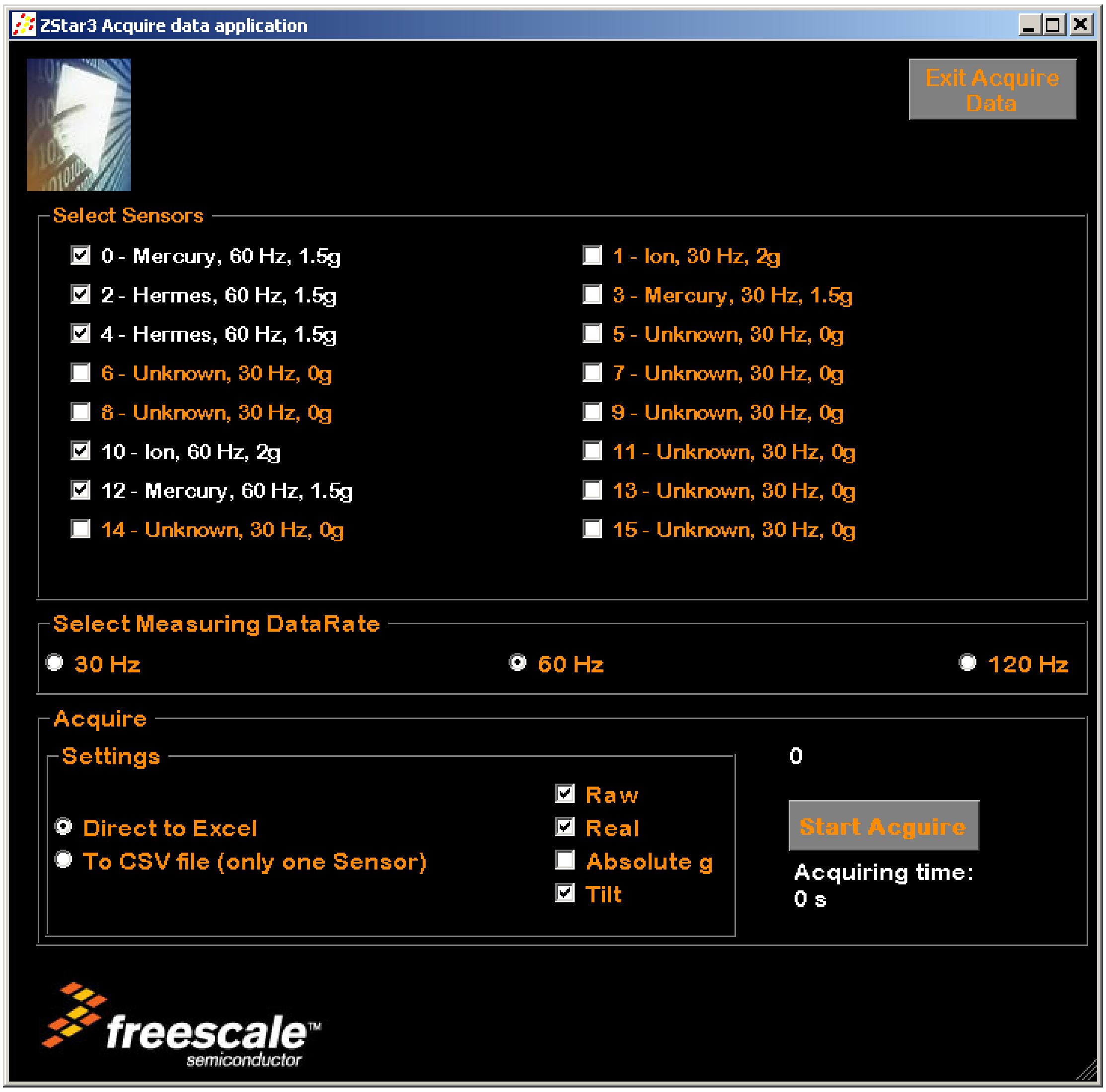
[1] Red numbers in picture marks individual controls described in list below.

7.2.5.2 Acquire data demo application

This application is designed to acquiring all maesured data from sensor. It allow select sensors to acquiring, select data rate of reading acceleration values, select which data will be saves and output of measured data. Thre are two choices of output:

- Direct to Microsoft Excel application (tested on Excel 2003 version).
- To CSV file - GUI save all measured data into text file that can be simply imported to Excel or another table application.

The capture time is not restricted..



Select Sensors

☑ 0 - Mercury, 60 Hz, 1.5g	□ 1 - Ion, 30 Hz, 2g
☑ 2 - Hermes, 60 Hz, 1.5g	□ 3 - Mercury, 30 Hz, 1.5g
☑ 4 - Hermes, 60 Hz, 1.5g	□ 5 - Unknown, 30 Hz, 0g
□ 6 - Unknown, 30 Hz, 0g	□ 7 - Unknown, 30 Hz, 0g
□ 8 - Unknown, 30 Hz, 0g	□ 9 - Unknown, 30 Hz, 0g
☑ 10 - Ion, 60 Hz, 2g	□ 11 - Unknown, 30 Hz, 0g
☑ 12 - Mercury, 60 Hz, 1.5g	□ 13 - Unknown, 30 Hz, 0g
□ 14 - Unknown, 30 Hz, 0g	□ 15 - Unknown, 30 Hz, 0g

Select Measuring DataRate

○ 30 Hz ◉ 60 Hz ○ 120 Hz

Acquire

Settings

◉ Direct to Excel
○ To CSV file (only one Sensor)

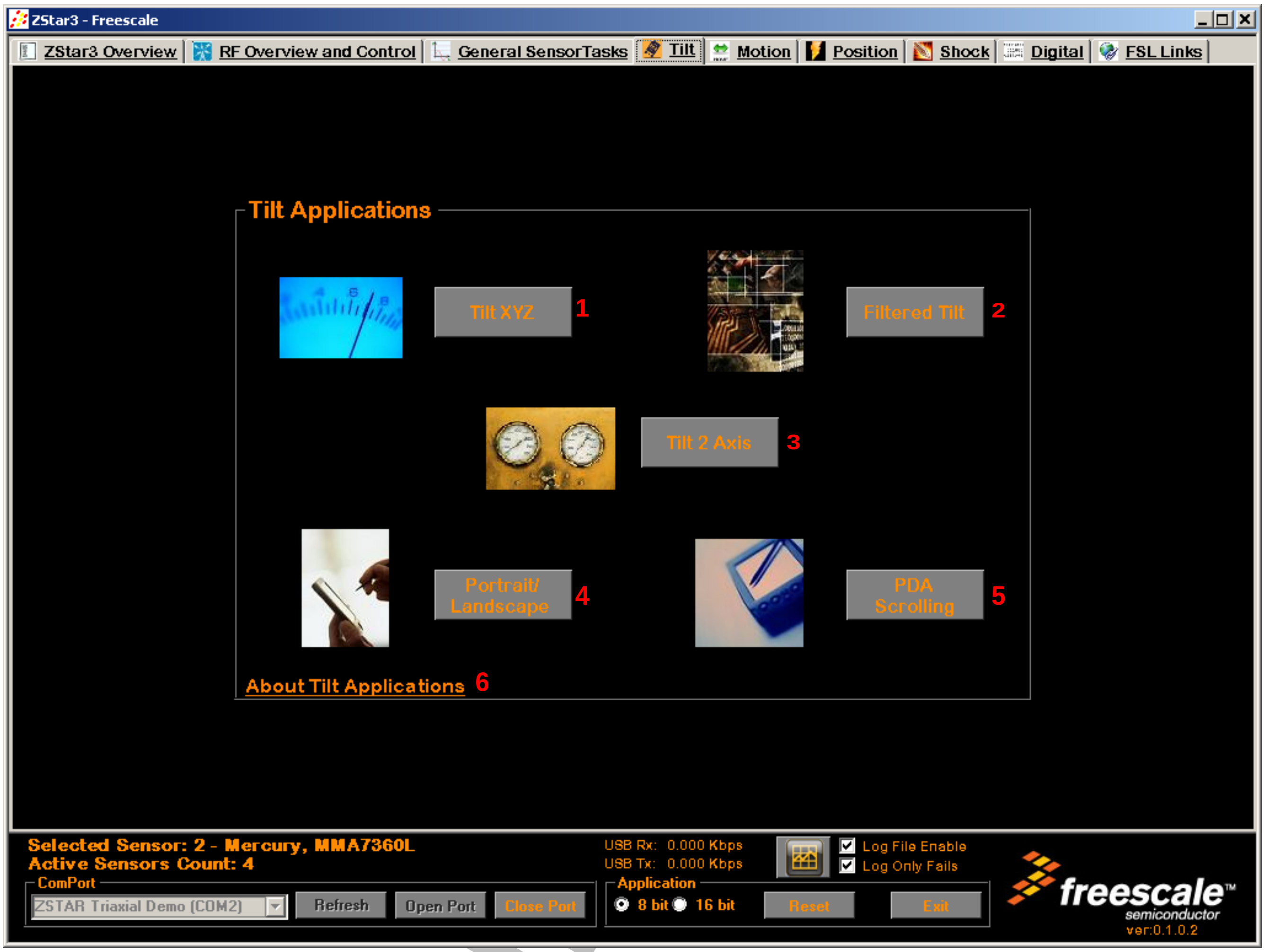
☑ Raw
☑ Real
□ Absolute g
☑ Tilt

0

Acquiring time:
0 s

Figure 7-11. Acquire data window

7.2.6 Tilt tasks



Selected Sensor: 2 - Mercury, MMA7360L
Active Sensors Count: 4
ZSTAR Triaxial Demo (COM2)
USB Rx: 0.000 Kbps
USB Tx: 0.000 Kbps
☑ Log File Enable
☑ Log Only Fails
● 8 bit ○ 16 bit
ver:0.1.0.2

Figure 7-12. The Tilt tasks screen.

The GUI Tilt tasks controls[1]:

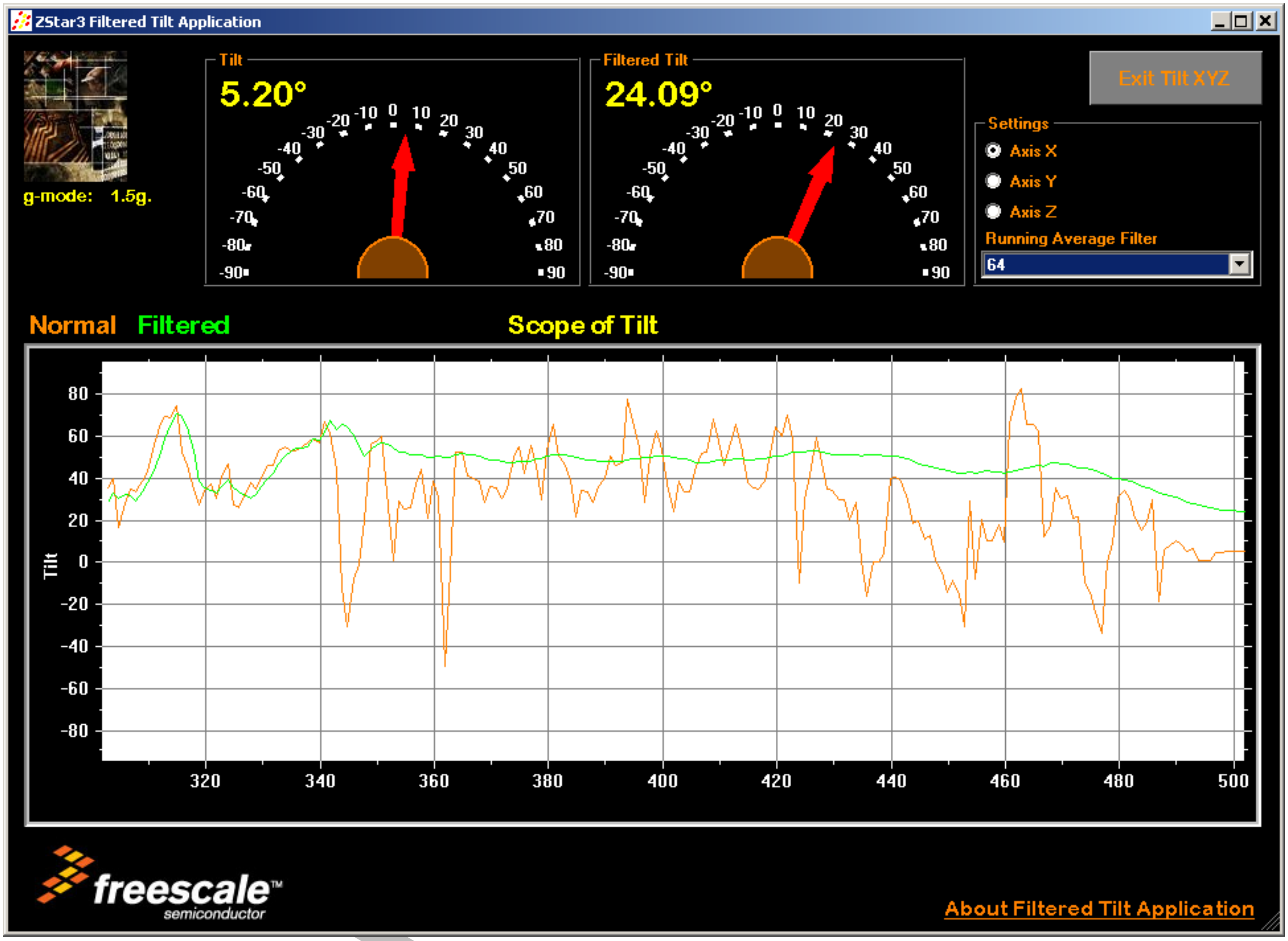
1. Tilt XYZ screen - Window shows tilt of all axes. Selectable normal / filtered values.
2. Filtered tilt - This application of the ZStar shows differencies beetwen normal measured tilt and filtered.
3. Tilt 2 Axes screen - This is special demo application that shows how can get from two axes full range of tilt 0° - 360°.
4. Portrait/Landscape screen - This demo shows one of couple detection tilt applications for PDA.
5. PDA Scrolling screen - This demo shows one of couple detection tilt applications for PDA.
6. About box - This about box content various information about Tilt accelerometers applications.

[1] Red numbers in picture marks individual controls described in list below.

7.2.6.1 Filtered tilt demo application

This demo window shows different between measured tilt values and software filtered. This demo is using basic average filter algorithm. On screen is placed four panels:

- Current measured tilt indicator.
- Filtered value of current measured value indicator.
- Setting box - there can be select measured axis of accelerometer and order of average filter up to 128 samples.
- Scope that shows differencies between current and filtered value in time.



zStar3 Filtered Tilt Application

g-mode: 1.5g.

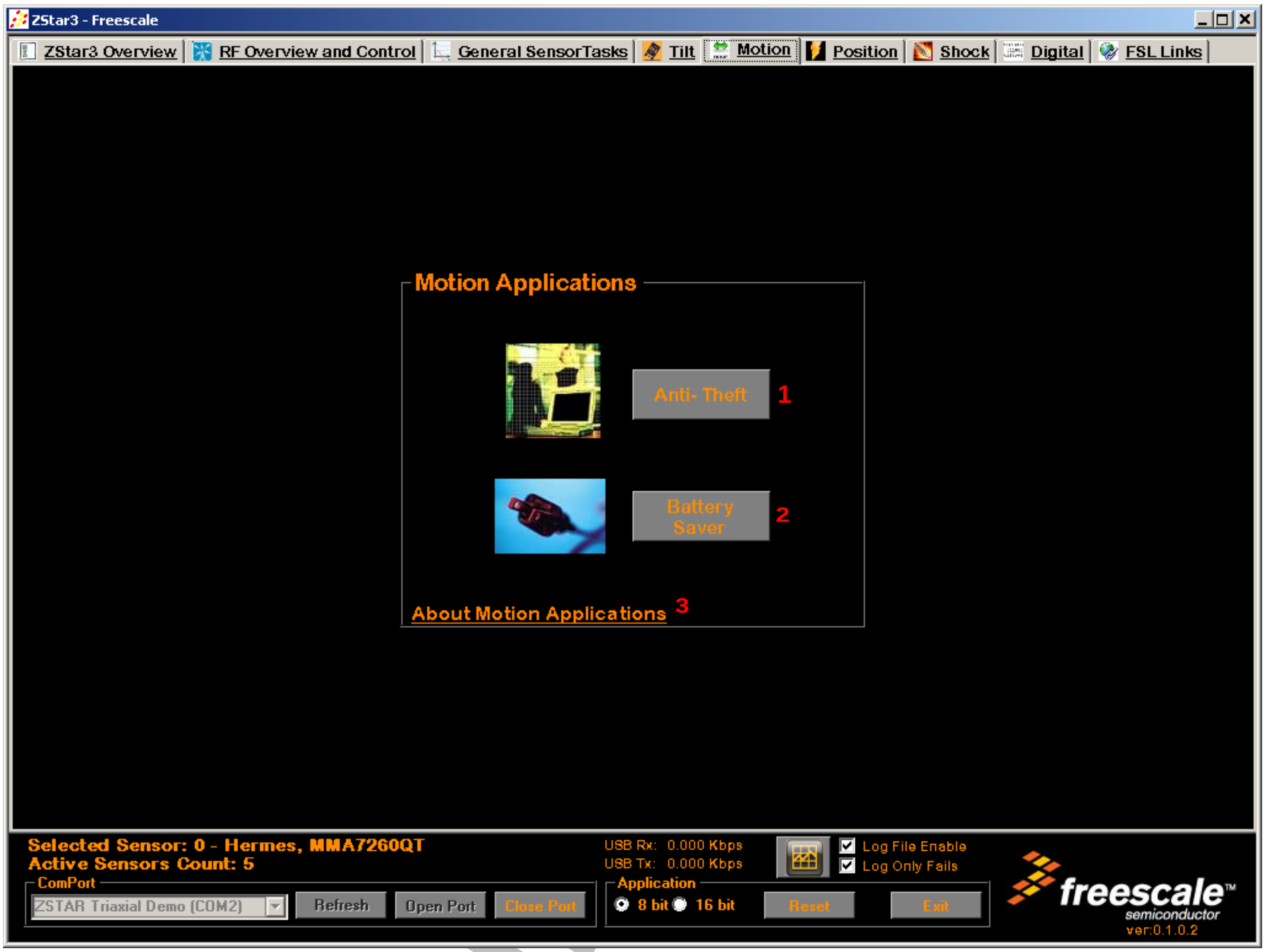
Tilt
5.20°

Filtered Tilt
24.09°

Settings
● Axis X
○ Axis Y
○ Axis Z
Running Average Filter
64

Figure 7-13. Filtered tilt demo application

7.2.7 Motion tasks



Selected Sensor: 0 - Hermes, MMA7260QT
Active Sensors Count: 5

USB Rx: 0.000 Kbps
USB Tx: 0.000 Kbps

☑ Log File Enable
☑ Log Only Fails

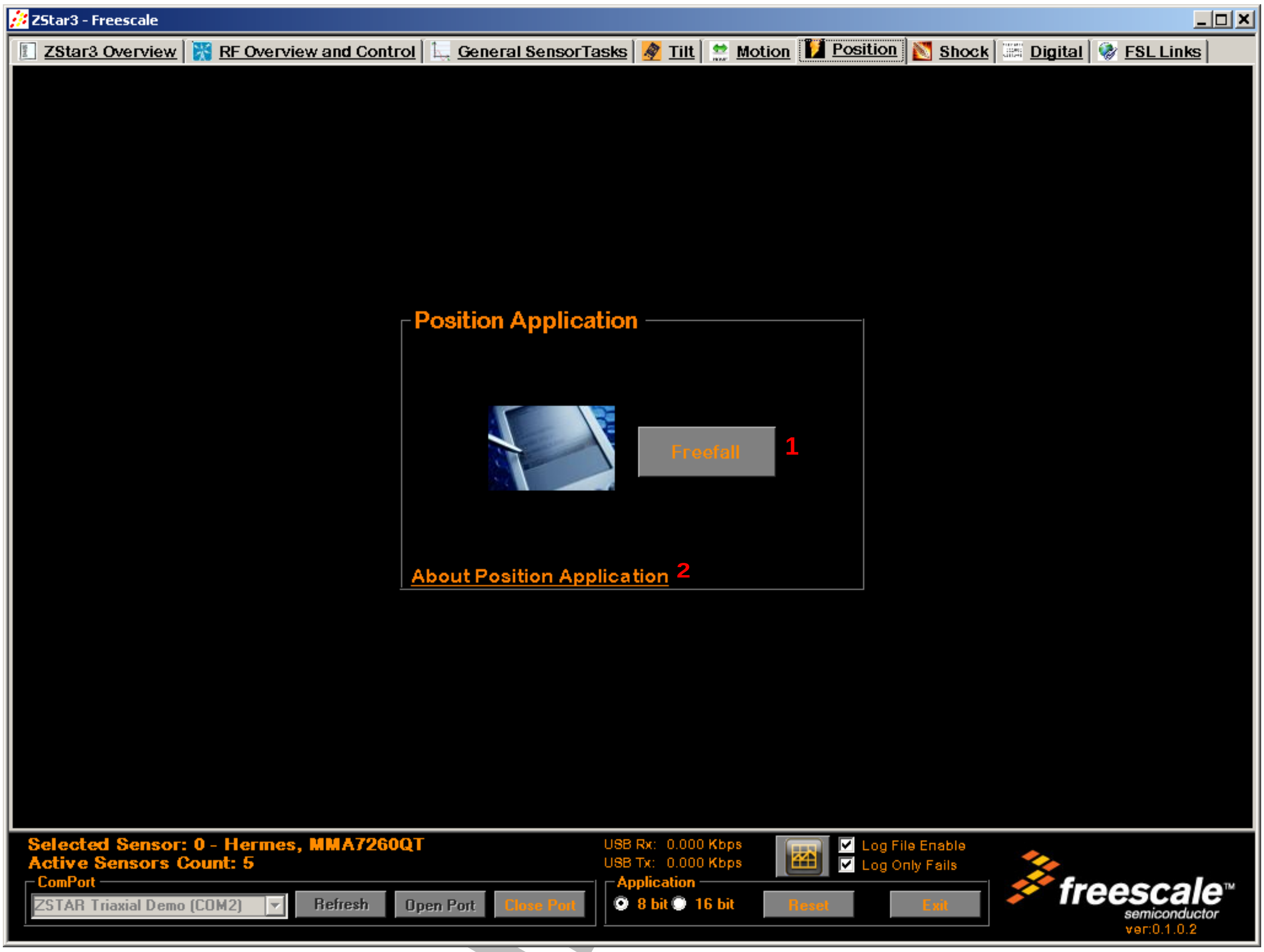
Figure 7-14. The Motion tasks screen.

The GUI Motion tasks controls[1]:

1. Anti-Theft screen - Window shows accelerometr posibilities in Anti - Theft applications.
2. Battery saver screen - This is demo that shows How can used accelerometers in some specific applications to save battery.
3. About box - This about box content various information about Motion accelerometers applications.

[1] Red numbers in picture marks individual controls described in list below.

7.2.8 Position tasks



Selected Sensor: 0 - Hermes, MMA7260QT
Active Sensors Count: 5

ZSTAR Triaxial Demo (COM2)

USB Rx: 0.000 Kbps
USB Tx: 0.000 Kbps

☑ Log File Enable
☑ Log Only Fails

● 8 bit ○ 16 bit

ver:0.1.0.2

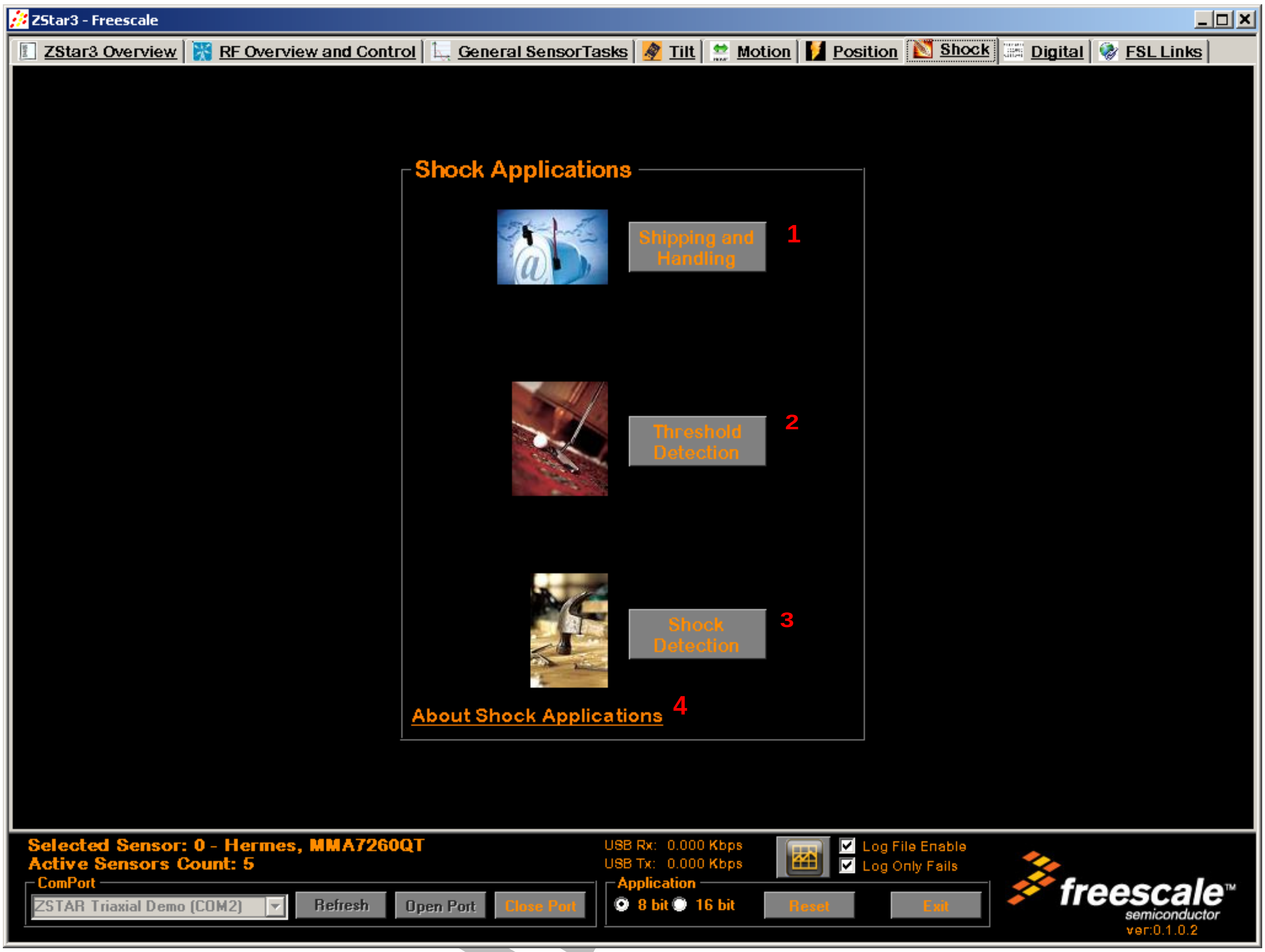
Figure 7-15. The Position tasks screen.

The GUI Position tasks controls[1]:

1. FreeFall screen - Demo shows accelerometer possibilities of FreeFall detection.
2. About box - This about box content various information about Position accelerometers applications.

[1] Red numbers in picture marks individual controls described in list below.

7.2.9 Shock tasks



Selected Sensor: 0 - Hermes, MMA7260QT
Active Sensors Count: 5

ZSTAR Triaxial Demo (COM2)

USB Rx: 0.000 Kbps
USB Tx: 0.000 Kbps

☑ Log File Enable
☑ Log Only Fails

● 8 bit ○ 16 bit

ver:0.1.0.2

Figure 7-16. The Shock tasks screen.

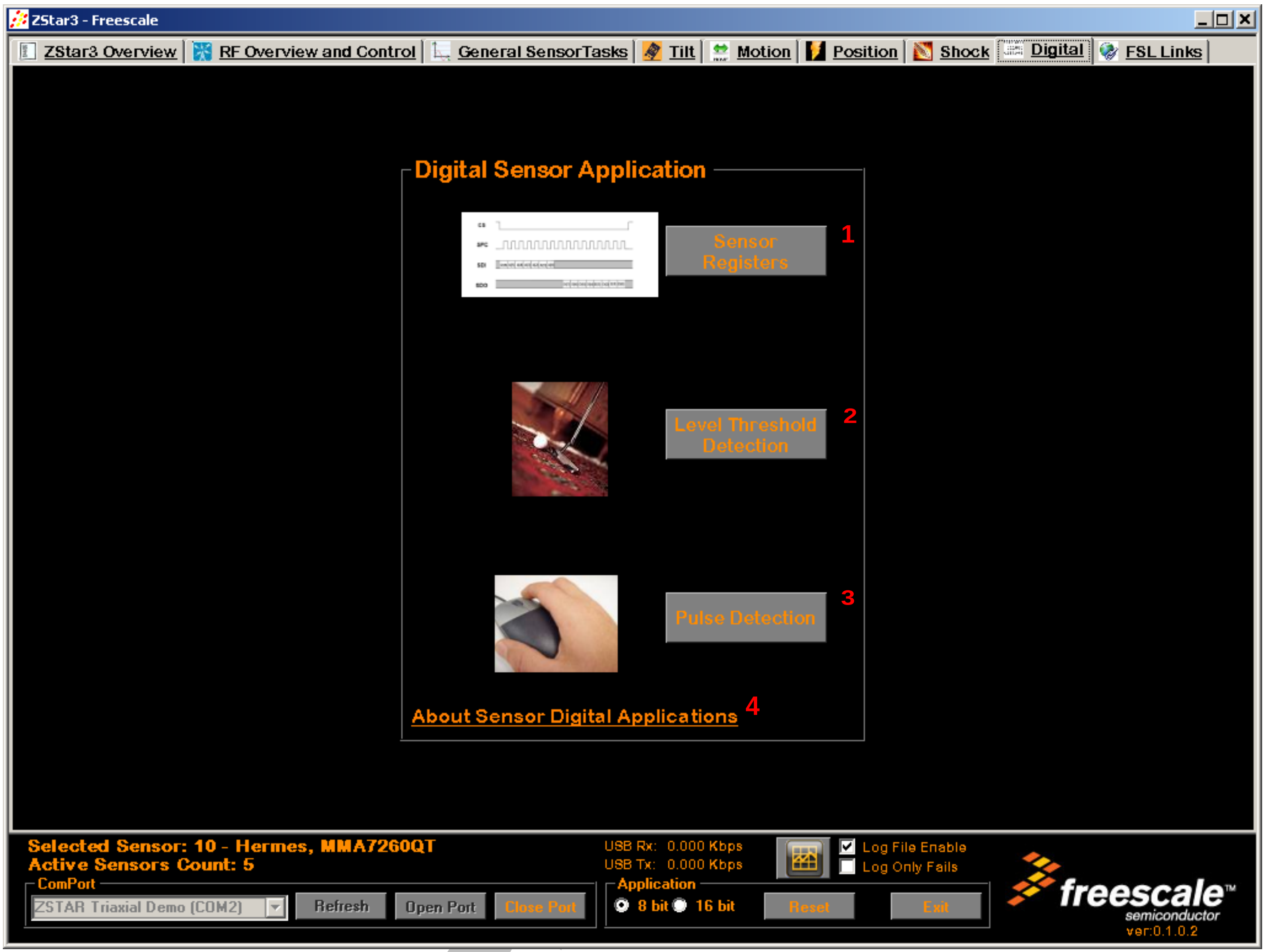
The GUI Shock tasks controls[1]:

1. Shipping and handling screen - This demo shows how can used accelerometers in Shipping.
2. Treshold Detection screen - This window shows measuring of g treshold by accelerometers.
3. Shock Detection screen - This window shows measuring peaks of g by accelerometers.
4. About box - This about box content various information about Shock accelerometers applications.

[1] Red numbers in picture marks individual controls described in list below.

7.2.10 Digital tasks

This tab contains specialy designed demos for Freescale digital accelerometer sensor(ION) MMA7450L.



Selected Sensor: 10 - Hermes, MMA7260QT
Active Sensors Count: 5
ZSTAR Triaxial Demo (COM2)
USB Rx: 0.000 Kbps
USB Tx: 0.000 Kbps
○ 8 bit ● 16 bit
☑ Log File Enable
□ Log Only Fails

Figure 7-17. The Digital tasks screen.

The GUI Digital tasks controls[1]:

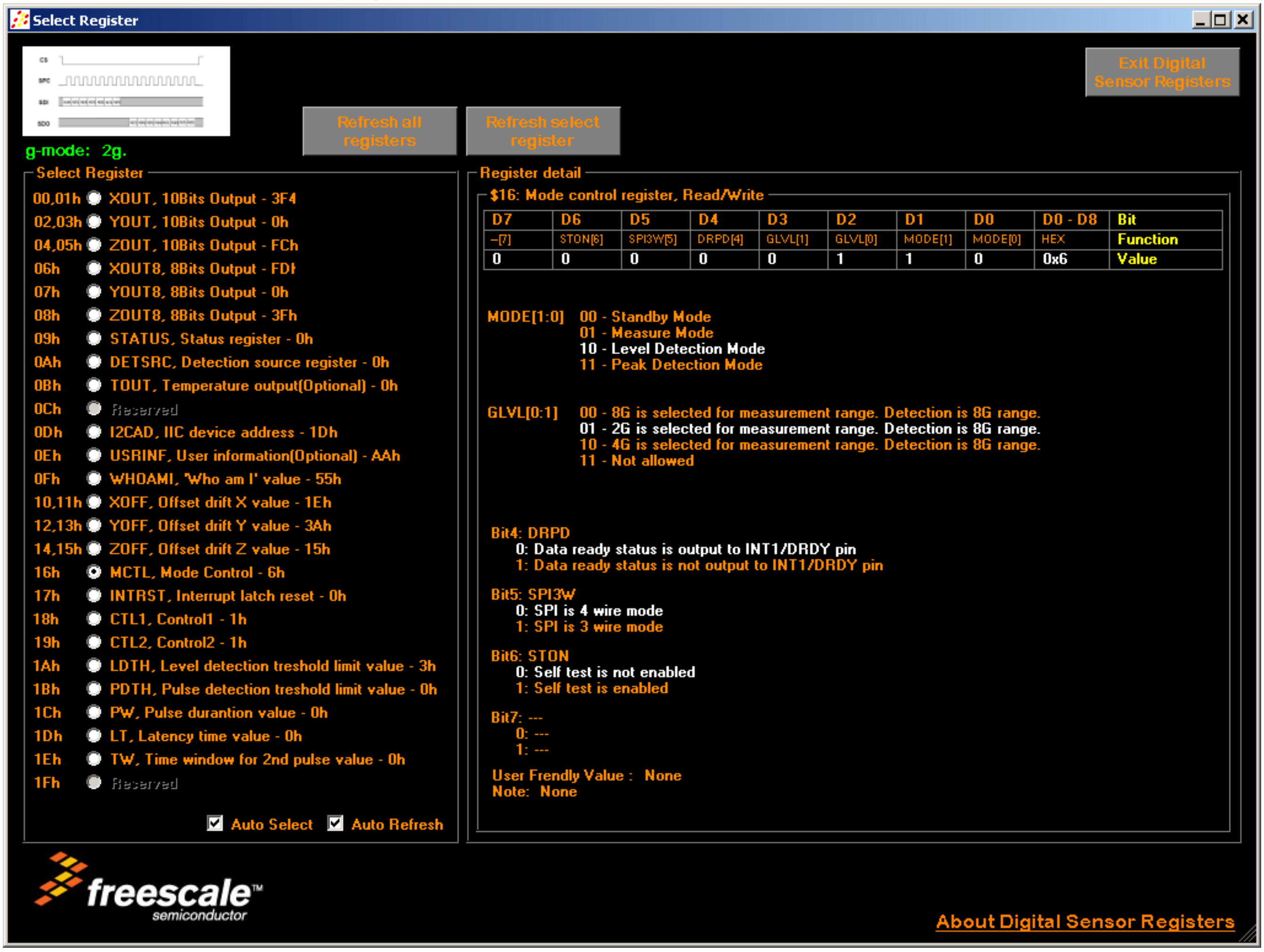
1. Sensor registers screen - This demo shows all regisers inside of digital sensor in user friendly format.
2. Level Treshold Detection screen - This window shows measuring of g treshold by digital accelerometers.
3. Pulse Detection screen - This window shows measuring pulses of g by digital accelerometers.
4. About box - This about box content various information about Freescale digital accelerometers applications.

[1] Red numbers in picture marks individual controls described in list below.

7.2.10.1 Sensor registers demo application

This is specially designed window that shows all internal registers of MMA745xL accelerometer. It is splited to two main parts:

- Left part contains list of all registers in MMA745xL accelerometer and its values in hex format. At bottom of this panel are placed two check boxes. First is Auto Select option, that allow fast mode selection of individual register, and second option allowed automaticaly refresh value of selected register.
- Content of right part is depend on left one. It shows details of selected register in friendly format. Active optins are displayed in white color.



g-mode: 2g.

Select Register

00,01h ○ XOUT, 10Bits Output - 3F4
02,03h ○ YOUT, 10Bits Output - 0h
04,05h ○ ZOUT, 10Bits Output - FCh
06h ○ XOUT8, 8Bits Output - FDł
07h ○ YOUT8, 8Bits Output - 0h
08h ○ ZOUT8, 8Bits Output - 3Fh
09h ○ STATUS, Status register - 0h
0Ah ○ DETSRC, Detection source register - 0h
0Bh ○ TOUT, Temperature output(Optional) - 0h
0Ch ○ Reserved
0Dh ○ I2CAD, IIC device address - 1Dh
0Eh ○ USRINF, User information(Optional) - AAh
0Fh ○ WHOAMI, 'Who am I' value - 55h
10,11h ○ XOFF, Offset drift X value - 1Eh
12,13h ○ YOFF, Offset drift Y value - 3Ah
14,15h ○ ZOFF, Offset drift Z value - 15h
16h ◉ MCTL, Mode Control - 6h
17h ○ INTRST, Interrupt latch reset - 0h
18h ○ CTL1, Control1 - 1h
19h ○ CTL2, Control2 - 1h
1Ah ○ LDTH, Level detection treshold limit value - 3h
1Bh ○ PDTH, Pulse detection treshold limit value - 0h
1Ch ○ PW, Pulse durantion value - 0h
1Dh ○ LT, Latency time value - 0h
1Eh ○ TW, Time window for 2nd pulse value - 0h
1Fh ○ Reserved

☑ Auto Select ☑ Auto Refresh

Register detail

$16: Mode control register, Read/Write

D7	D6	D5	D4	D3	D2	D1	D0	D0 - D8	Bit
–[7]	STON[6]	SPI3W[5]	DRPD[4]	GLVL[1]	GLVL[0]	MODE[1]	MODE[0]	HEX	Function
0	0	0	0	0	1	1	0	0x6	Value

MODE[1:0] 00 - Standby Mode
01 - Measure Mode
10 - Level Detection Mode
11 - Peak Detection Mode

GLVL[0:1] 00 - 8G is selected for measurement range. Detection is 8G range.
01 - 2G is selected for measurement range. Detection is 8G range.
10 - 4G is selected for measurement range. Detection is 8G range.
11 - Not allowed

Bit4: DRPD
0: Data ready status is output to INT1/DRDY pin
1: Data ready status is not output to INT1/DRDY pin

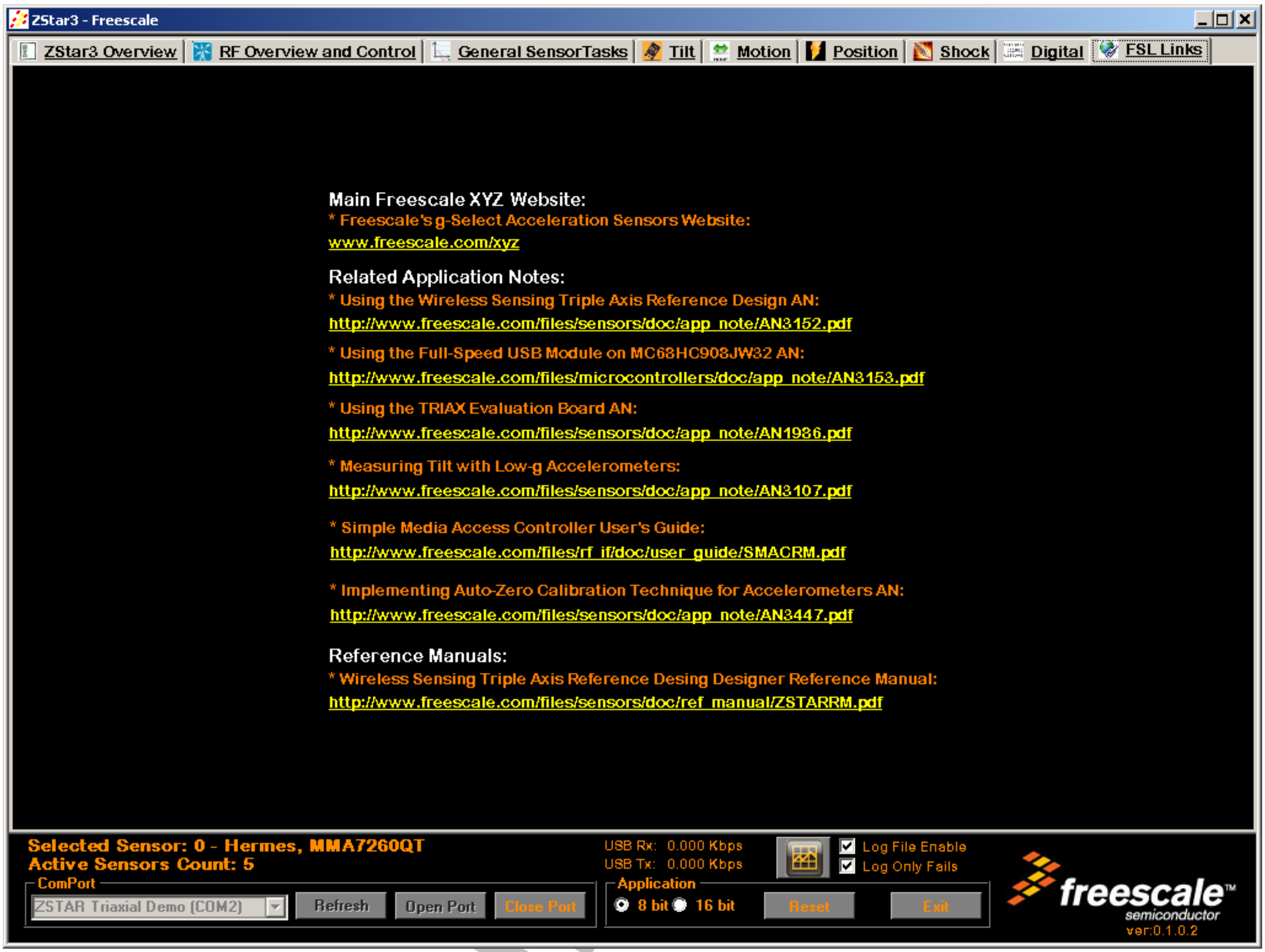
Bit5: SPI3W
0: SPI is 4 wire mode
1: SPI is 3 wire mode

Bit6: STON
0: Self test is not enabled
1: Self test is enabled

Bit7: ---
0: ---
1: ---

User Frendly Value : None
Note: None

7.2.11 Freescale Web Links.



Main Freescale XYZ Website:
* Freescale's g-Select Acceleration Sensors Website:
www.freescale.com/xyz

Related Application Notes:
* Using the Wireless Sensing Triple Axis Reference Design AN:
http://www.freescale.com/files/sensors/doc/app_note/AN3152.pdf

* Using the Full-Speed USB Module on MC68HC908JW32 AN:
http://www.freescale.com/files/microcontrollers/doc/app_note/AN3153.pdf

* Using the TRIAX Evaluation Board AN:
http://www.freescale.com/files/sensors/doc/app_note/AN1986.pdf

* Measuring Tilt with Low-g Accelerometers:
http://www.freescale.com/files/sensors/doc/app_note/AN3107.pdf

* Simple Media Access Controller User's Guide:
http://www.freescale.com/files/rf_if/doc/user_guide/SMACRM.pdf

* Implementing Auto-Zero Calibration Technique for Accelerometers AN:
http://www.freescale.com/files/sensors/doc/app_note/AN3447.pdf

Reference Manuals:
* Wireless Sensing Triple Axis Reference Desing Designer Reference Manual:
http://www.freescale.com/files/sensors/doc/ref_manual/ZSTARRM.pdf

Selected Sensor: 0 - Hermes, MMA7260QT
Active Sensors Count: 5

USB Rx: 0.000 Kbps
USB Tx: 0.000 Kbps

☑ Log File Enable
☑ Log Only Fails

● 8 bit ○ 16 bit

ver:0.1.0.2

Figure 7-18. The Links screen.

This screen contains couple of interesting links about Freescale and its accelerometric sensors.

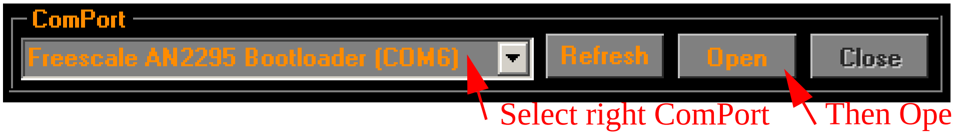
7.3 The ZStar3 GUI Update USB Stick Software utility

The ZStar3 GUI can easily upgrade firmware in USb Stick by Bootloader capatibily. There are two different ways how to start upgrade utility:

- Self-acting start - GUI always check software version of USB Stick with open port action. If it find older version that it has, then GUI show information message with ask of start of software update utility.
- Manual start - GUI can open direct registered Bootloader Com port.

7.3.1 Update process (Manual start)

1. For manual start select Bootloader Com port[1] from Comport list and press Open button.



ComPort

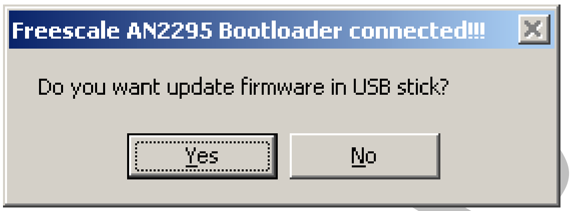
Freescale AN2295 Bootloader (COM6)

Select right ComPort

Then Open this port

Figure 7-19. Update software procedure - step1

2. When the GUI show the a Information message box about Update procedure, click on OK button to continue.

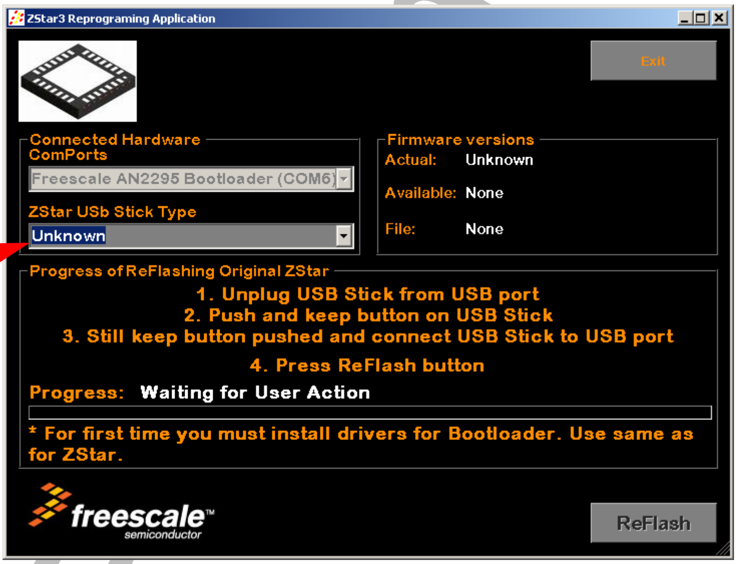


Freescale AN2295 Bootloader connected!!!

Do you want update firmware in USB stick?

Figure 7-20. Update software procedure - step2

3. Now the GUI shows the Update window. On it it has to be selected right type of the currently connected ZStar USB Stick.



ZStar3 Reprograming Application

Connected Hardware

ComPorts: Freescale AN2295 Bootloader (COM6)

ZStar USb Stick Type: Unknown

Firmware versions

Actual: Unknown

Available: None

File: None

Progress of ReFlashing Original ZStar

1. Unplug USB Stick from USB port
2. Push and keep button on USB Stick
3. Still keep button pushed and connect USB Stick to USB port
4. Press ReFlash button

Progress: Waiting for User Action

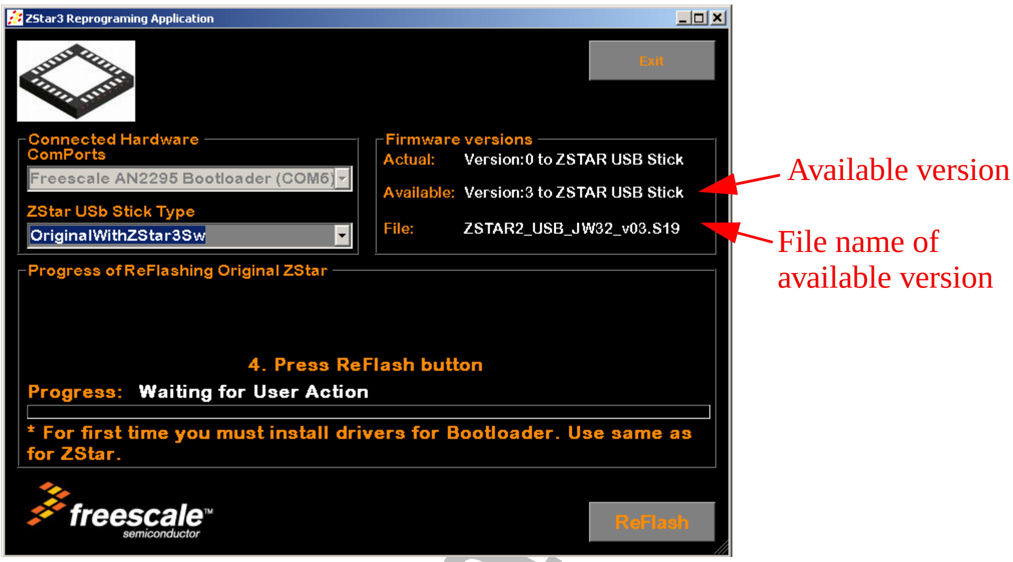
* For first time you must install drivers for Bootloader. Use same as for ZStar.

Select type of the USB Stick

Figure 7-21. Update software procedure - step3

[1] Bootloader port is started by procedure described in Section 5.6.1, “Switch to Bootloader procedure.

4. When you select right type of USB Stick, the GUI know which files it has and offer latest version of available software.



Connected Hardware ComPorts: Freescale AN2295 Bootloader (COM6)

ZStar USb Stick Type: OriginalWithZStar3Sw

Firmware versions

Actual: Version:0 to ZSTAR USB Stick

Available: Version:3 to ZSTAR USB Stick

File: ZSTAR2_USB_JW32_v03.S19

Progress of ReFlashing Original ZStar

4. Press ReFlash button

Progress: Waiting for User Action

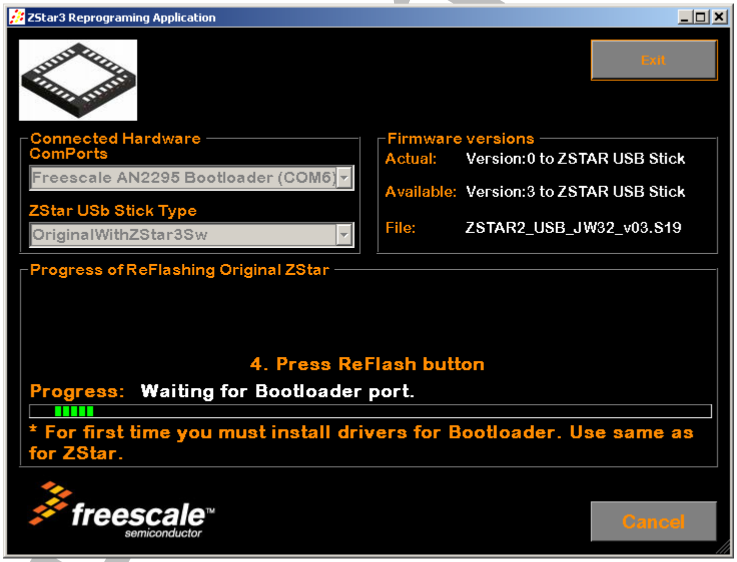
* For first time you must install drivers for Bootloader. Use same as for ZStar.

Available version

File name of available version

Figure 7-22. Update software procedure - step4

5. Now you can press ReFlash button. The GUI starts looking for a available Bootloader port.



Connected Hardware ComPorts: Freescale AN2295 Bootloader (COM6)

ZStar USb Stick Type: OriginalWithZStar3Sw

Firmware versions

Actual: Version:0 to ZSTAR USB Stick

Available: Version:3 to ZSTAR USB Stick

File: ZSTAR2_USB_JW32_v03.S19

Progress of ReFlashing Original ZStar

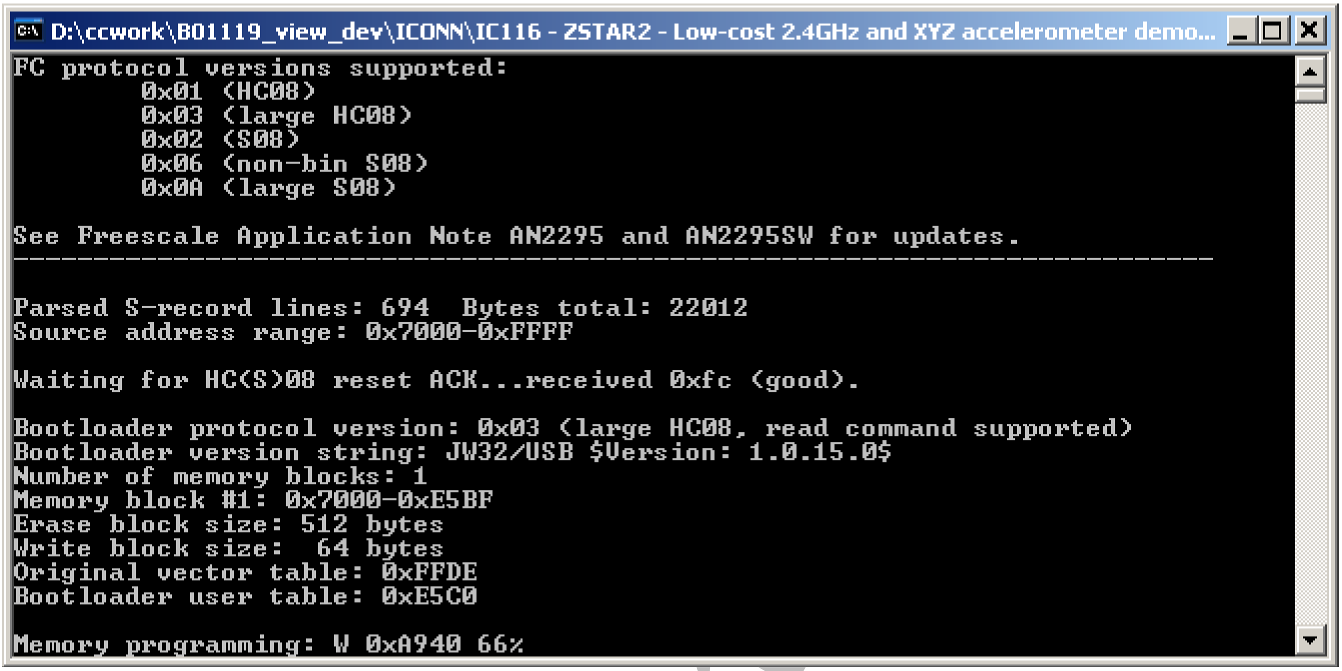
4. Press ReFlash button

Progress: Waiting for Bootloader port.

* For first time you must install drivers for Bootloader. Use same as for ZStar.

Figure 7-23. Update software procedure - step5

6. When the GUI found a Bootloader port, the original bootload procedure starts. Please wait to end of bootloader process.



D:\ccwork\B01119_view_dev\ICONN\IC116 - ZSTAR2 - Low-cost 2.4GHz and XYZ accelerometer demo...

```
FC protocol versions supported:
        0x01 (HC08)
        0x03 (large HC08)
        0x02 (S08)
        0x06 (non-bin S08)
        0x0A (large S08)

See Freescale Application Note AN2295 and AN2295SW for updates.
---------------------------------------------------------------------------

Parsed S-record lines: 694  Bytes total: 22012
Source address range: 0x7000-0xFFFF

Waiting for HC(S)08 reset ACK...received 0xfc (good).

Bootloader protocol version: 0x03 (large HC08, read command supported)
Bootloader version string: JW32/USB $Version: 1.0.15.0$
Number of memory blocks: 1
Memory block #1: 0x7000-0xE5BF
Erase block size: 512 bytes
Write block size:  64 bytes
Original vector table: 0xFFDE
Bootloader user table: 0xE5C0

Memory programming: W 0xA940 66%
```

Figure 7-24. Original bootloader application

When Update process finish success, close update window and enjoy all new features that brings new version of the ZStar firmware.

Appendix A
References

The following documents can be found on the Freescale web site: http://www.freescale.com.

1. AN2295 Application note - Developer’s Serial Bootloader for M68HC08 and HCS08 MCUs
2. AN3153 Application note - Using the Full-Speed USB Module on the MCHC908JW32
3. AN3447 Application note - Implementing Auto-Zero Calibration Techniquefor accelerometers
4. ZSTARRM Reference design manual - Original ZSTAR demo(RD3152MMA7260Q) RDM
5. MC9S08QG8 data sheet
6. MCHC908JW32 data sheet
7. MMA7260QTT data sheet
8. MMA7360LT data sheet
9. MMA7450L data sheet
10. MC13191 data sheet
11. MC13213 data sheet