

## **DEVICE CONTROLLED BY JAVA**

### **Zařízení řízené pomocí prostředí Java**

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*Abstract:* Java language becomes to be very popular past few years. Many of universities started developing their own applications, libraries or whole enterprises solutions. The big advantage of this language is its freedom of choices. Maybe that's why becomes to be very popular even among students. You can find lot of opensource projects and developed applications. You can join this project as developer or you can contribute to any of them with any ideas of improvements. For age Java language was limited by its usage for computer systems or mobile phones. It was because there was implemented Java Virtual Machine which is needed for its initiation. Last year time changed and Sun presented Small Programmable Object technology to public. This device gives opportunity to developers to work with Java language, sensors and real devices together. More detail will be mentioned in this article.

*Key words:* Java, Sun SPOT, Java Virtual Machine, Squawk, Sensor, Communication, Accelerometer

#### **1. Introduction**

Project Sun SPOT (Sun; Small Programmable Technology) is a snapshot of ongoing research in Sun Microsystems Laboratories [3]. In 2003 researchers at these laboratories began working on Wireless Sensor Networks. Over course of the first year of research, they found that they wanted more powerful sensor devices that were easier to program [6]. They thought that Java language helped them to get past some of limits that showed up. In November 2004 started project SPOT to build their own sensor hardware and to adapt a small, flexible Java Virtual Machine (Project Squawk) [8][9] to the sensor platform. Within days of development were shown many of ideas for SPOT usage. Outcome of this research is device where is running Java Virtual Machine called Squawk. To the SPOT you are able to attach sensor board with sensors. Through this sensor board you are also able to connect other sensors, servo motor or other supported device. This fact gives to developers many opportunities of usage and creates their ideas real in the simple way. One of the biggest advantages is ability to control or program all connected devices by Java programming language. This makes usage of Sun SPOT very simple and easy to learn as you can see below.

## 2. Hardware inside the Sun SPOT

A SPOT device is built by stacking a processor board with a sensor board and battery. For better imagination it's created by three slices (Figure 1). Hurt of the SPOT is on processor board. There is ARM920T processor who is running on 180 MHz and is created by 32-bit technology. Operation memory is 512K RAM and flash memory is 4 MB. Processor board contains also integrated radio antenna on 2.4 GHz IEEE 802.15.4. By this antenna device can communicate with other devices. On this board is also USB interface, connector for 3.7 rechargeable 720 mAh lithium-ion battery and 32 uA deep sleep mode.



Figure 2-Sun SPOT anatomy [2]

Better overview of the main board concept [2] can be seen on the Figure 3.

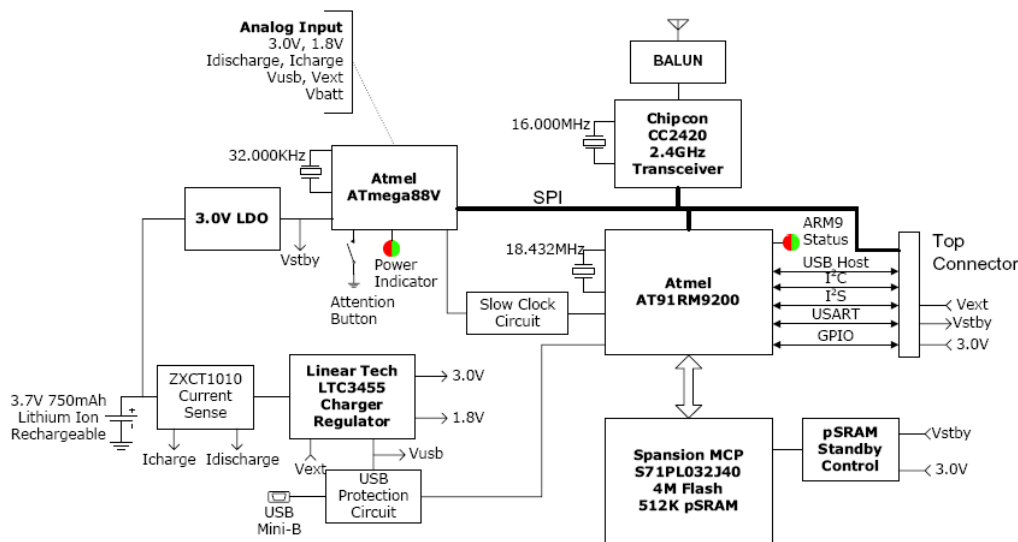


Figure 3- Main board concept

## 3. Sensor board

Sensor board [2] is very important part of whole device. It is connected to processor board and contains sensors. Installed demo sensors are light and temperature sensors, 2G/6G 3-axis accelerometer, eighth 3-colors LED diodes and 4 high current output pins and an ACD.

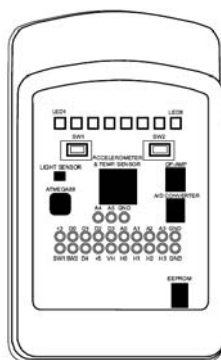


Figure 4- Sensor board schema

Whole sensor board is controlled by Atmega88 processor who is communicating with main board over the SPI channel as a slave device. The Atmega88 processor provides interrupts the ARM9 processor, controls mode bits on the accelerometer, scan analog inputs and reports digitized values.

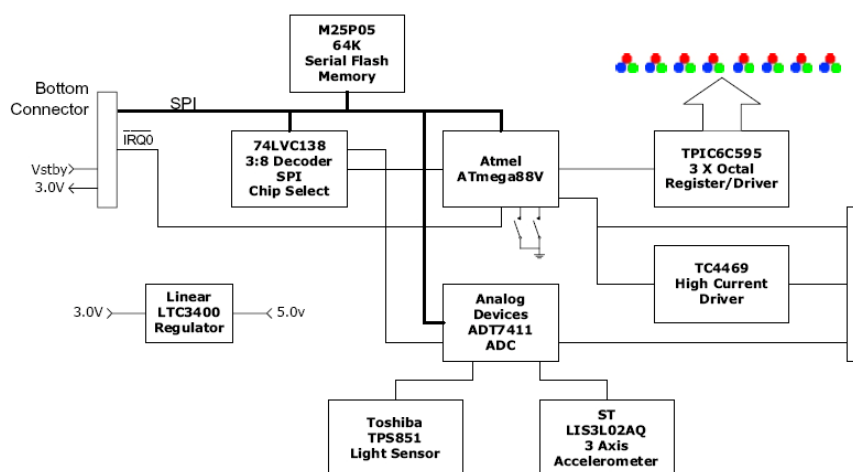
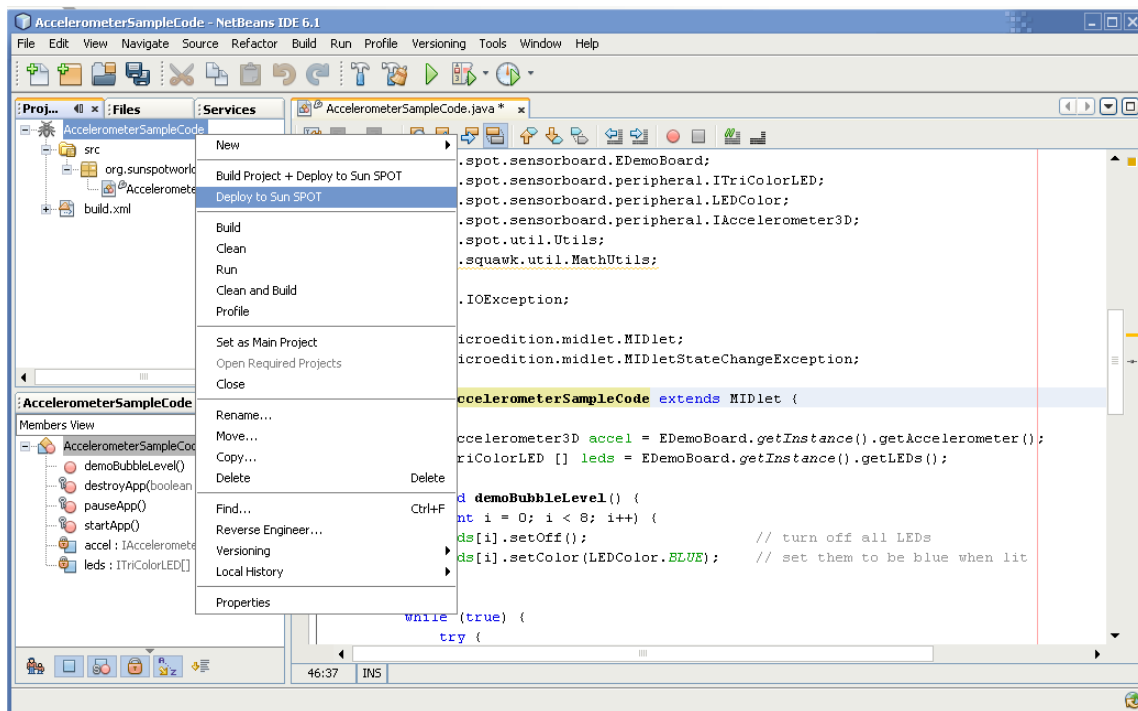


Figure 5 - Sensor board concept

#### 4. Introduction to developing application for Sun SPOT

Developing application [1] for this device is quite simple. Developer needs only Java language [6] and Apache Ant project [4] as the build manager. Ant is mapping all needed libraries. For more comfortable applications programming you can use IDE like NetBeans [7] or Eclipse. All SPOT demos you are able to open inside IDE and also you are able to deploy your developed application directly to the Sun SPOT. Application deployment you can do by USB port or over the air through the basestation (with Ant [4] script usage). The basestation is the same device like the SPOT. It's created only by main board. On the main board there is the radio antenna as I have written upon. If the deployment is successful you can reset your Sun SPOT and start to use your developed application.



*Figure 6 - NetBeans accelerometer demo*

When you are developing application [1] for SPOT device it's very important to know something. The main class of your SPOT application has to extend MIDlet interface (Example 2). This interface implements three members *startApp()*, *pauseApp()* and *destroyApp()*. For more information you can see manuals [2][1]. At the start of all application you have to also import sun spot libraries (Example 1).

```
import com.sun.spot.sensorboard.EDemoBoard;
import com.sun.spot.sensorboard.peripheral.ITriColorLED;
import com.sun.spot.sensorboard.peripheral.LEDColor;
```

*Example 1 - library import*

```
public class AccelerometerSampleCode extends MIDlet {
```

*Example 2 - MIDlet usage*

After you have imported all necessary libraries you can use sensors installed or connected to the sensor board (Example 3). In this part I have used 3-D accelerometer which will be described more detailed latter in the article.

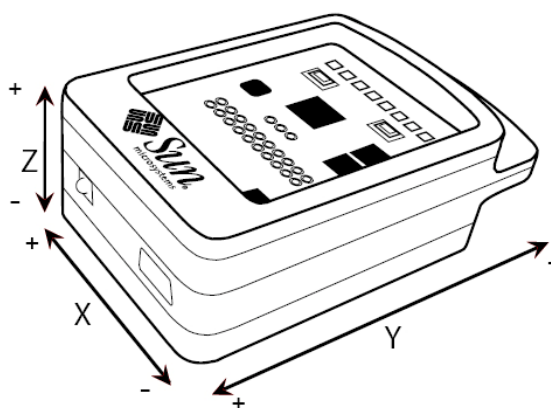
```
private IAccelerometer3D accel =
EDemoBoard.getInstance().getAccelerometer();
private ITriColorLED [] leds = EDemoBoard.getInstance().getLEDs();
```

```
public void demoBubbleLevel() {
    for (int i = 0; i < 8; i++) {
        leds[i].setOff(); // turn off all LEDs
```

*Example 3 - Peripheral devices on sensor board*

## 5. Accelerometer sensor

I decide to use accelerometer sensor based on the demo sensor board [5] (Figure 31) because it shows every nicely how Sun SPOT is working with. The Z axis is perpendicular to the board surface, the Y axis is parallel with the board surface perpendicular with the row of LEDs, and the X axis is parallel with the row of LEDs (**Chyba! Nenalezen zdroj odkazů.**). This accelerometer has three voltage outputs  $V_{out\_x}$ ,  $V_{out\_y}$ ,  $V_{out\_z}$  representing acceleration in 3-D axis.



*Figure 7 - Accelerometer axes orientation*

The force accelerating the Sun SPOT in any dimension is measured in g-force units.

$$g = \frac{ADC - 465.5}{186.2} \quad (5.1)$$

For each axis, the maximum sample rate is 160Hz. The capacitors C5-C7 [2](Figure 31) provide a single pole low pass filter to band limit the accelerometer. The frequency of this limit is

$$F_t = \frac{1}{2\pi \cdot R_{out} \cdot Cf(x, y, z)} \quad (5.2)$$

C5-C7 are  $0.01 \mu F$  capacitors and  $R_{out}$  is 100K internal resistance of the accelerometer. Therefore the cutoff frequency  $F_t$  is 160Hz.

## 6. Summary of Sun SPOT usage

In the end of this article I want to motion important fact of this device. This device is giving opportunity to use and increase your Java language knowledge. It's easy to program and to deploy it into device. Systems of devices can communicate together over the air by radio antenna usage. Standard Java applications can be also developed. Client's applications

are called host's applications. Host application can run up on any computer system (Windows, Mac OS, Linux, UNIX, and Solaris) and you can through the basestation control all installed Sun SPOTs. It's meant control all SunSPOTs over the air through the basestation.

These facts create from Sun SPOT very powerful device not only a toy. It can be used for building robot or sensors station. It can be used also for technology demonstration for students. By sensors connected to the Sun SPOT you can measure every value you want. Sun SPOT system can be also used for presentation of the faculty or university. In current version there is developed very sophisticated emulator. This emulator gives opportunity to develop application without real Sun SPOT needs. Every student could try Sun SPOT out at home.

## References

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