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Embedded platforma pro vývoj didaktických pomůcek

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GENERAL DESCRIPTION

This development platform could be used as a base system for developing of didactical aids. It consists of many ready-to-use components that help developer with the didactical aid implementation. HW documentation and basic Firmware code are prepared for the quick rapid prototyping.

FEATURES AND RATINGS

- Supply voltage: 4,5 to 40VDC
- based on ATxmega32A4U microcontroller[1]
- supports USB, SPI, UART, I2C, GPIO interfaces
- On board Accelerometer, Haptic Feedback (vibration), Communication Module 868MHz
- Dimensions of PCB board: 42 x 50mm

PROTOTYPE PHOTOS

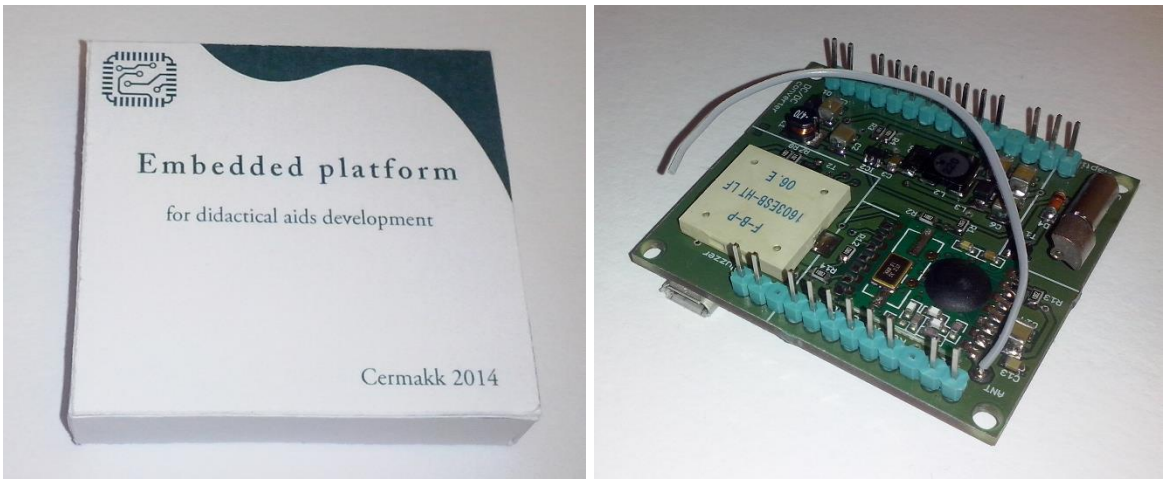

Figure 1. Prototype photo.

HW DESCRIPTION

The development platform contains of one PCB board that is distributed in the paper package. The dimensions of PCB is 42 x 50mm and contains of many ready-to-use components that help with the didactical aid development and implementation. The board could be divided into several small sections (see Figure 2). The heart of the platform is ATxmega32A4U microcontroller. For powering the device the DCDC converter from various input voltage to 3.3V is implemented. The interconnection to the microcontroller is provided by followed blocks:

1) Status LEDs – Red and Green LED are prepared to show the status of the unit
2) UART Interface – Asynchronous Serial interface (3.3V Level)
3) Digital I/O – 8 configurable Digital Inputs/Outputs to/from microcontroller
4) Analog I/O – 2 analog inputs and 1 analog output from microcontroller
5) USB Interface – for programming and communication with PC
6) I2C Interface – two wire interface for connecting various devices
7) SPI – three wire synchronous serial interface for connecting various devices

[1]) http://www.atmel.com/Images/Atmel-8387-8-and16-bit-AVR-Microcontroller-XMEGA-A4U_Datasheet.pdf 1

Beside of these HW blocks, four following blocks are prepared as ready-to-use blocks, as they will be rapidly used in didactical aids:

8) Remote control – Radio module (868MHz) for communication with PC or Handheld remote controller
9) Accelerometer – digital 3 axis MEMS sensor for reading of aid movement and orientation in free space
10) Speaker output – amplified output for generating various sounds
11) Haptic feedback – control of vibrating motor for haptic feedback

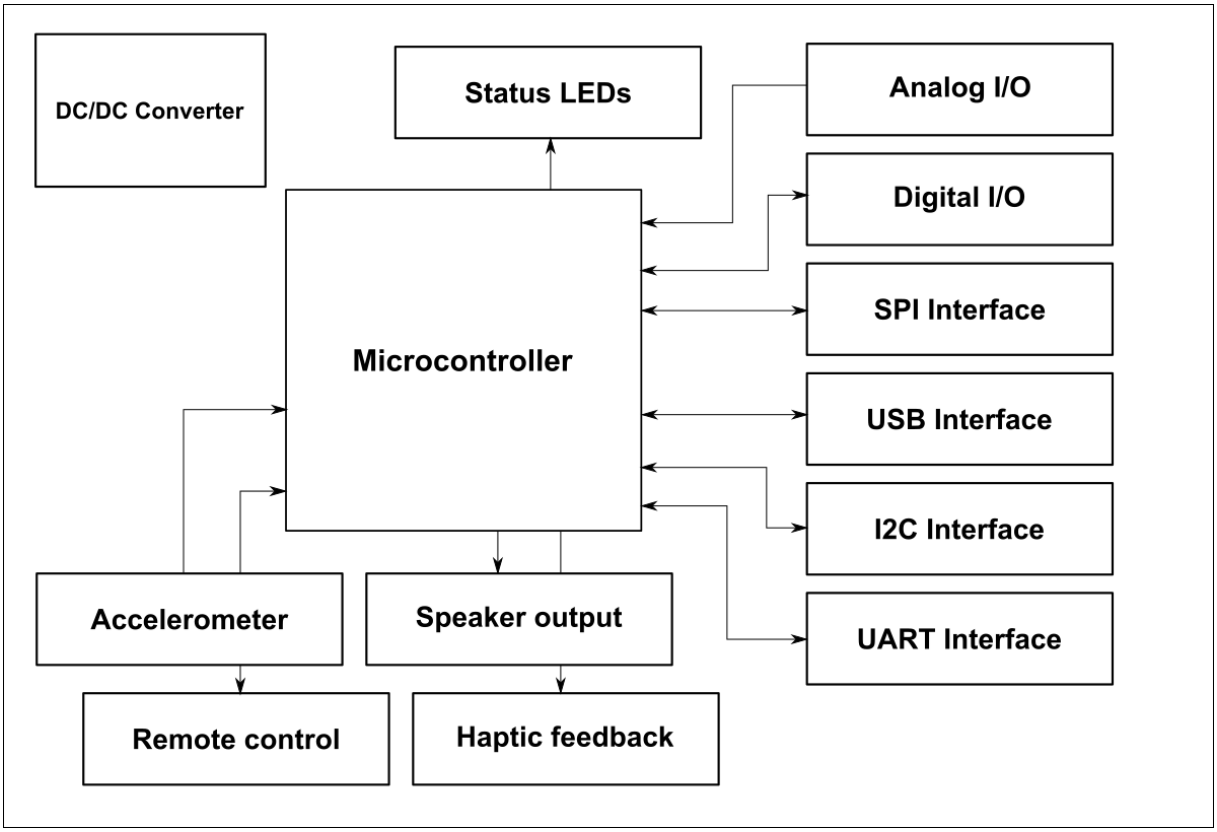

Figure 2. Block schematic of embedded platform.

Schematic of particular blocks are presented in the chapter Electrical schematics. Starting with power supply (Figure 7) the battery could be connected to connector CN1 with respecting the battery polarity. Silicon diode D1 protects the device from reversing polarity. It also separates the battery when the USB connection is used. Resistors R1 and R2 create a voltage divider and provide a feedback to microcontroller AD converter for measuring the battery voltage. Capacitors C1 and C2 together with choking coil L1 provide supply voltage filtering for IC2 LM2842 that is designed as a Step-down converter with high efficiency. The output feedback, behind the main coil L2, is created with R3 and R4. The voltage division is calculated so the output voltage is exactly 3.3V. Behind the regulator the output filter with C4 and C5 is made. From this node the other blocks are supplied. For supplying the AD converter in microcontroller the additional filter with L3, C6 and C7 is used. This circuit is provided in the Application note AVR1018 from Atmel.

The heart of the device is IC1, the microcontroller Atmel ATxmega32A4U (Figure 3). C8 to C10 are filter capacitors connected as close as possible to the microcontroller package. The firmware could

be flashed through PDI connector CN2. There are two LEDs connected to the microcontroller through the series resistors. These could be used as a "status" LEDs providing optical feedback to user. Microcontroller's pins are divided into 5 segments that respect the block figure 2. These are: Digital IOs, Analog IOs, SPI Interface, I^2C Interface, and UART Interface. Through these blocks it is possible to expand the base board with several external functional blocks.

In the Figure 4 there is a schematic of the Haptic feedback, Speaker output and Accelerometer. Transistor T1 and diode D4 is used to drive the vibration motor that is connected direct to connector CN3. Speaker output consists of transistor T2, resistors R7 and R8 connected to the piezo buzzer BUZ1. The accelerometer IC4 is attached direct to the I^2C interface of the microcontroller. Capacitors C11 and C12 are used as supply filters, pull-up resistors R10, R11 are used with respecting the I^2C communication needs. Pin CS is connected to supply voltage so the communication mode is set to I^2C instead of SPI.

Figure 5 shows the schematic of the USB communication interface. The microcontroller has dedicated internal USB interface so only connector CN4 and ESD protection of communication lines are needed. Diode D2 separates the USB voltage form the battery voltage if the battery is used.

In the figure 6 the remote control bases on radio module IC3 is shown. This module mainly communicated with the microcontroller through the SPI communication interface but it also need several supporting signals and two pull-up resistors R12 and R13. Capacitors C13 and C14 are used as a supply filters. There is also a wire antenna attached to the radio module. The length is close to the $\lambda/4 \approx 8{,}6\text{cm}$.

Based on the electrical schematic the PCB layout was made, resulting in double sided PCB board with dimensions 42 x 50mm.

FW DESCRIPTION

With the Embedded platform it is possible to start the firmware development. The easiest way to start with is an easy-to-use tool chain from the manufacturer of ATxmega32A4U microcontroller – Atmel Studio IDE that supports code development and simulation in C language or assembler. During the development of the Embedded platform for didactical aids there were a lot of code pieces written in C. These were cleaned up and arranged into several libraries to make the start of coding easier. This is the list of prepared libraries:

1) MCU Initialization – basic setting of microcontroller based on Block schematic (Figure 2)
2) Status Indication – setting of Status LEDs and predefined macros for status indication
3) Battery Management – measuring of battery voltage and configuration of various low-power modes
4) I2C Interface – initialization of I^2C microcontroller component and basic procedures for sending and receiving data
5) SPI Interface – initialization of SPI microcontroller component and basic procedures for sending and receiving data
6) UART Interface – initialization of UART microcontroller component and basic procedures for sending and receiving data
7) ECC – functions for encoding and decoding data based on Reed-Muller error correction code RM(1,5)

8) Remote control – initialization of radio module and basic functions for sending and receiving data in 868MHz baseband.

Firmware could be uploaded to Embedded platform via PDI programming interface or through the USB with Atmel FLIP programming tool. Libraries could be downloaded from cermakk.cz/embeddedplatform.

ELECTRICAL SCHEMATICS

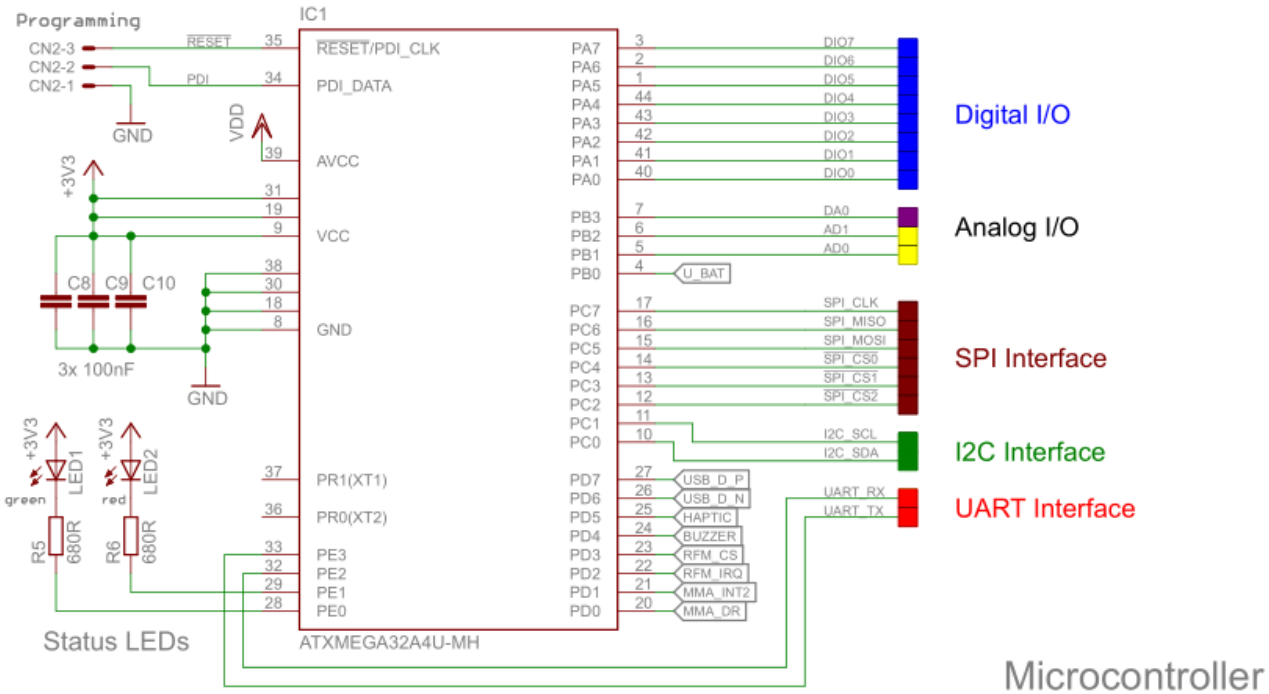

Figure 3. Schematic of the microcontroller and IOs.

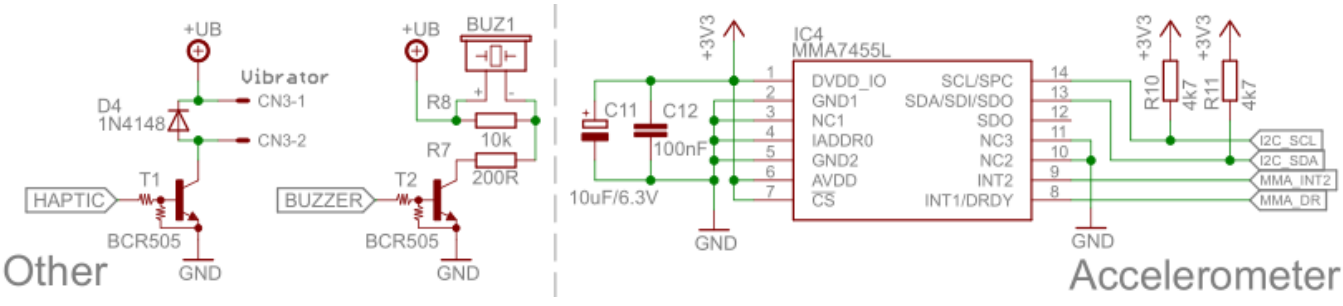

Figure 4. Schematic of the Haptic Feedback, Speaker output and Accelerometer.

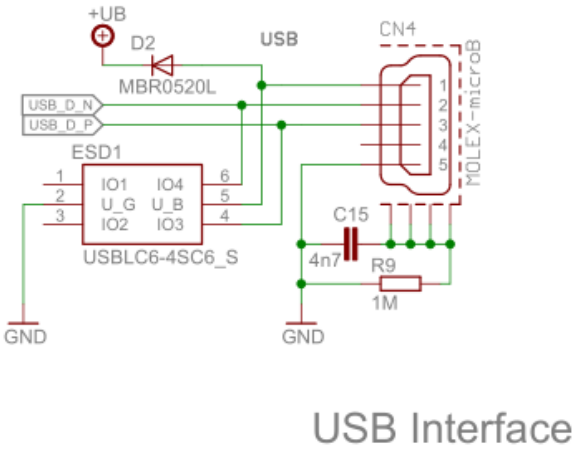

Figure 5. Schematic of USB connection.

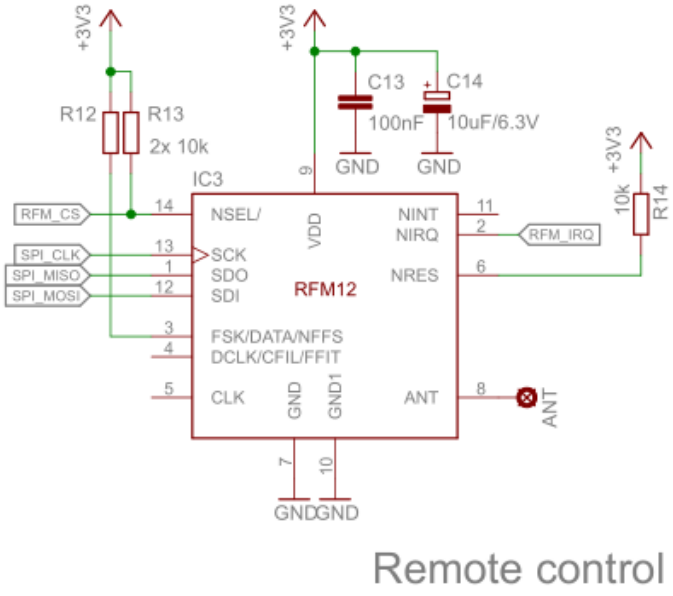

Figure 6. Schematic of radio module.

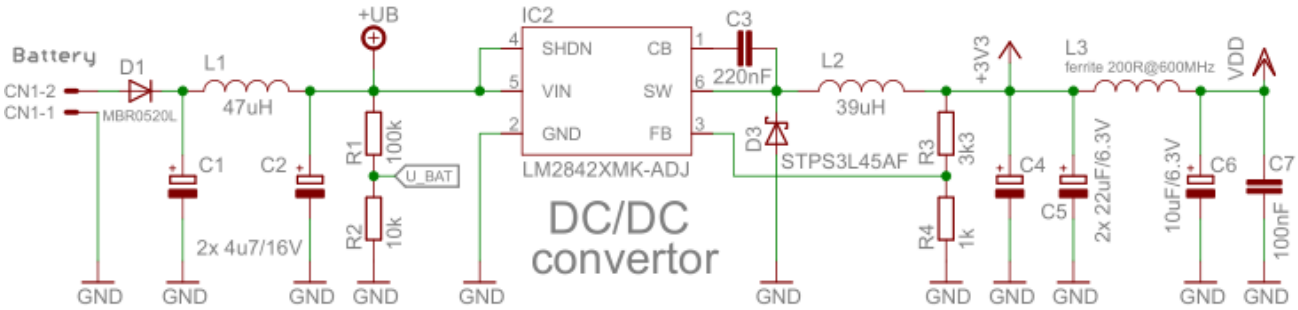

Figure 7. Schematic of Power supply.

FABRICATION OUTPUTS

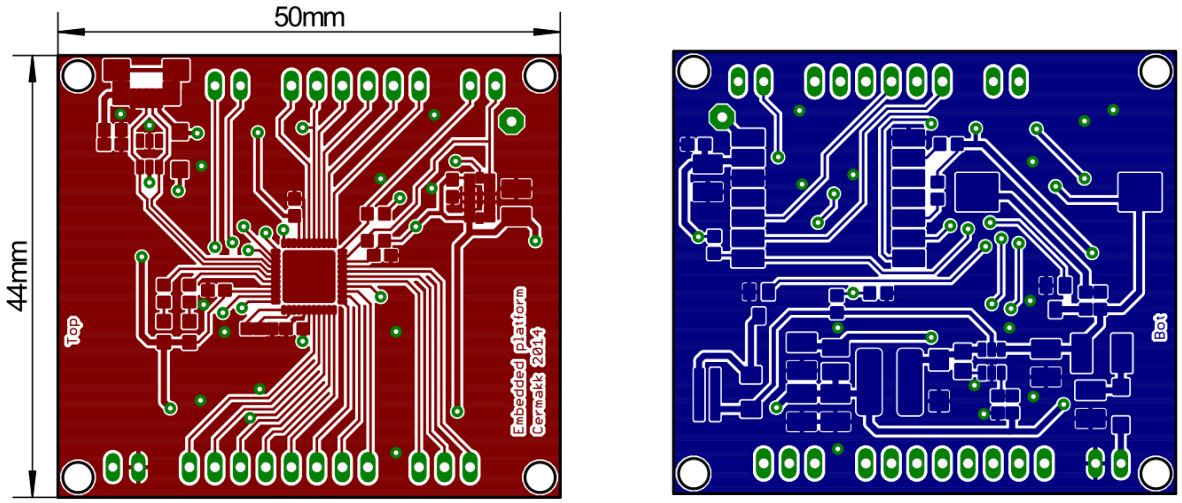

Figure 8. Top and Bottom copper layer.